JANUARY 1930.] [Price 8s.

PROCEEDINGS

OF

THE LINNEAN SOCIETY OF LONDON.

141ST SESSION.

FROM NOVEMBER 1928 TO MAY 1929.

LONDON:
PRINTED FOR THE LINNEAN SOCIETY OF LONDON,
BURLINGTON HOUSE, PICCADILLY, W. 1,
BY TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.

THE LINNEAN SOCIETY OF LONDON.

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1928–29.

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PROCEEDINGS

OF

THE LINNEAN SOCIETY OF LONDON.

THE LINNEAN SOCIETY OF LONDON.
Proceedings, 140th Session (1927–28).

ERRATUM.

p. 94, first reference :
for "New Zealand" *read* "New England."

FROM NOVEMBER 1928 TO MAY 1929.

LONDON:
PRINTED FOR THE LINNEAN SOCIETY OF LONDON,
BURLINGTON HOUSE, PICCADILLY, W.1.
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THE LINNEAN SOCIETY OF LONDON.

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H.R.H. THE PRINCE OF WALES, K.G., F.R.S.

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PUBLICATIONS: From June 1928–May 1929.

Journal, Botany.

Vol. XLVIII. No. 320.

„ 321.

Journal, Zoology.

Vol. XXXVI. No. 248.

„ 249.

Proceedings, 140th Session, November 1928.

List of The Linnean Society of London, Nov. 1928.

PROCEEDINGS

OF

THE LINNEAN SOCIETY OF LONDON.

(ONE HUNDRED AND FORTY-FIRST SESSION, 1928–1929.)

GENERAL MEETINGS.

1st November, 1928.

Sir Sidney F. Harmer, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the Anniversary Meeting, held on Thursday the 24th May, 1928, having been circulated, were taken as read and confirmed.

A list of names of those who had made gifts to the Library since the 24th May, 1928, was read and laid on the table.

The following were admitted Fellows:—Aldewin Cecil Ibbotson, Edwin Harold Brown, and John Humphrey Bell.

Certificates of recommendation of the following candidates for Fellowship were read:—For the second time in favour of James Percival Tufnell Burchell, Miss Daphne Aubertin, and Malcolm Arthur Smith. For the first time in favour of Russell Solomon, Mrs. Lucy Howland, Frederick Sydney Banfield, John Frederick Vicars Phillips, Frederick Whalley Sansome, John Oliver Borley, Cecil Prescott Hurst, Miss Lilian Mary Joy, George Evelyn Hutchinson, George Stuart Carter, James Erik Hamilton, William Alexander Francis Balfour-Browne, George Olds Cooper, Miss Nora Cameron Rogers, and Arthur Francis Bulmer Standfast.

Mr. V. S. Summerhayes (Visitor) gave a paper—illustrated with lantern-slides—embodying the results of his revision of the

Australian species of *Frankenia*. The following is an abstract of his paper:—

During the last 65 years our knowledge of the Australian species of *Frankenia* has increased enormously. Bentham in 'Flora Australiensis' (1863) described seven species and three varieties. In 1918 Ostenfeld enumerated fifteen species from Western Australia alone, while the number actually described up to 1925 was twenty-one. In the present paper forty-four species are recognized.

Among the most important characters for taxonomic purposes are the arrangement and number of ovules, and the nature of the leaves. Niedenzu in 'Die Naturliche Pflanzenfamilien' divided the genus into two subgenera—*Afra* and *Oceania*—and the latter, containing the Australian species, into the sections *Toichogonia* and *Basigonia*, the former characterized by numerous parietal ovules, and the latter by a single basal ovule to each placenta. Examination shows that there is a series of ovular arrangements leading insensibly from *Toichogonia* to *Basigonia*.

The genus *Frankenia* actually seems to be composed of a number of parallel evolutionary series progressing from the "toichogonial" to the "basigonial" stage, although the final stages have not been reached in all the series. The American species with basal ovules seem to have had a different origin from the Australian ones. Evolution in the leaf-characters has probably occurred from the petiolate to the sessile types. This is supported by the fact that the sessile-leaved species all belong to one group which in ovular characters can be considered rather advanced.

On the whole the genus may be looked upon as an ancient one, which in Australia has found favourable conditions, and which has consequently produced many species there. Western Australia appears to be the original home of the genus in the continent; the species have spread eastwards into the new country rendered available by the elevation of the land-mass.

Mr. T. A. Sprague congratulated Mr. Summerhayes on the accomplishment of a very important piece of work, based on the examination of the Australian material of *Frankenia* in the principal herbaria of the world.

In reply to questions by Dr. A. B. Rendle and Mr. A. W. Exell, the author stated that the leaf-characters could not be held to form a basis for dividing the genus into primary sections, but merely furnished a means of indicating relations. He could not at the present stage state what was likely to happen to Niedenzu's names in the event of a rearrangement of the species in the genus.

Dr. Helene E. Bargmann gave an account—illustrated with lantern-slides—of her investigations into the morphology of the

central nervous system in the Gastropoda Pulmonata. The following is an abstract of her paper:—

The visceral ganglia in the Pulmonata exhibit a tendency to become concentrated in the course of their evolution, and examination of a considerable amount of material indicates the fact that there are eight types into which the Pulmonate nervous system can be divided, according to the degree and mode of concentration of the visceral ganglia. These types are fairly sharply defined, but there are instances in which it is difficult to decide the type to which the nervous system belongs.

Variation in the type of nervous system takes place within families and within genera, but variation within species is slight and not enough to affect the combination of the ganglia as a whole.

Comparison of the grouping of the nervous system under eight types, with groupings based on systematic classification, reveals in some cases very clearly that affinities are by no means well understood, and that our present method of indicating affinity by the systematic treatment of single organ systems may involve very serious contradictions and anomalies.

The President congratulated Dr. Bargmann on the interest of her paper and gave a general commentary on the results.

Prof. E. W. MacBride asked for a definition of the word "snail." Was it used to denote air-breathing Euthyneura? He was very interested to hear that *Cheilina*, if it really is a member of the air-breathing Euthyneura, retained a twisted nerve-loop. This was usually associated with a very large shell. Had Dr. Bargmann considered the theory of neurobiotaxis, that two ganglia in constant close connection in transmitting stimuli moved nearer to one another?

Dr. G. P. Bidder, like Prof. MacBride, wished to hear Dr. Bargmann's views as to the reason of the approximation and confluence of ganglia in Mollusca and Arthropoda. From the velocity of the nervous impulse, the time taken to traverse a centimetre of nerve-cord was so short that its abbreviation must be unimportant in a slow-moving animal. Would it be possible, however, that the shortening of the connecting nerve had the advantage of allowing the transference of a feebler impulse?

In reply Dr. Bargmann expressed her agreement with the remarks of Prof. MacBride and Dr. Bidder, and explained that while practical considerations had restricted her investigation to the morphological aspect of the nervous system, which formed the subject of her paper, she cherished hopes of extending her researches in the future.

Miss T. L. Prankerd explained the results of her continued studies in the Geotropism of Pteridophyta, the subject of her paper being Specificity in Graviperception.

Upwards of 2000 experiments had been made on the fronds of seven species of ferns in order to determine quantitatively their reaction to gravity at different stages in their ontogeny. The results can be expressed as curves, termed *graviscripts*, which naturally fall into two groups corresponding to the two genera—*Asplenium* and *Osmunda*—into which these species have long been grouped on morphological grounds. Response to stimulus is thus shown to afford criteria of taxonomic value, and may therefore be taken into account by the systematist who believes that all characters must carry weight in a truly Natural System.

Some generalizations were tentatively put forward with regard to the geotropic irritability of ferns; and it was claimed that *Osmunda cinnamomea*, which will under certain conditions respond to a stimulus lasting only twenty seconds, is the most sensitive plant to the force of gravity as yet discovered.

Mr. J. Ramsbottom remarked on the interest of physiological experiments which did not require a mass of expensive apparatus. Commenting on the suggested use of physiological criteria in systematy, he pointed out the use which has to be made of these in distinguishing between the numerous strains found to exist in many genera of fungi.

In reply to questions by Miss M. Williams, the author stated that there was no sharply-defined receptive region in the fern frond, and that there was only a rough correlation between changes in sensitivity and alterations in tissue.

15th November, 1928.

Sir Sidney F. Harmer, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous Meeting, held on Thursday the 1st November, 1928, having been circulated, were taken as read and confirmed.

A list of names of those who had made gifts to the Library since the previous Meeting was read and laid on the table.

The following were admitted Fellows:—Hugh Hamshaw Thomas and John Macqueen Cowan.

Certificates of recommendation of the following candidates for Fellowship were read:—For the second time in favour of Russell Solomon, Mrs. Lucy Howland, Frederick Sydney Banfield, John Frederick Vicars Phillips, Frederick Whalley Sansome, John Oliver Borley, Cecil Prescott Hurst, Miss Lilian Mary Joy, George Evelyn Hutchinson, George Stuart Carter, James Erik

Hamilton, William Alexander Francis Balfour-Browne, George Olds Cooper, Miss Nora Cameron Rogers, and Arthur Francis Bulmer Standfast. For the first time in favour of Miss Anna McClean Bidder, Miss Susan Finnegan, Miss Anna Birchall Hastings, Frank William Jane, Stanley Wells Kemp, Miss Eileen Reed, and William Keble Martin.

The following candidates were balloted for and elected Fellows:—James Percy Tufnell Burchell, Miss Daphne Aubertin, and Malcolm Arthur Smith.

Dr. H. Hamshaw Thomas gave an account, illustrated with lantern-slides, of further observations on the cuticle structure of Mesozoic Cycadean Fronds.

The paper was a continuation of the results communicated to the Society in 1913 by the author and Dr. N. Bancroft (Trans. Linn. Soc., Bot. vol. viii, p. 155), and dealt with the cuticle structure of a further selection of mesozoic cycad-like fronds. Some of these belong to genera represented in the previous paper, but are species differing in age and locality from the types there described. They had been examined with a view to showing the range of variation which occurs in the epidermal structures of different species referable to the same genus, and consequently testing the systematic value of cuticle characters. The cuticles of several species of *Pterophyllum* had also been examined, since the delimitation of this genus and of some of its constituent species have been the source of much discussion. The work shows that the typical members of the genus are widely different in their epidermal structure from the fronds which have often been placed with them as the section *Anomozamites*, and indicates that the latter must have belonged to plants which were generically distinct.

The rare Yorkshire plant named by Prof. Seward *Dioonites Nathorsti* and later *Pterophyllum Nathorsti* is figured for the first time. Its cuticle structure shows that it should be regarded as the type of a new genus. Some of the numerous forms of *Pterophyllum* from the Lunz Beds (Upper Trias) of Austria had been re-examined, and the conclusion reached that there is no justification for the separation of these well-graded forms into a number of species distinguishable by their dimensions ("breadth-index"), but that they should be regarded as different forms of the same species. This involves a change in the current nomenclature. Cuticle structure indicates that the Palæozoic fronds from the Coal Measures of Blanzy and Commentry in France, described some time ago by Zeiller as species of *Pterophyllum*, should be regarded as allied more closely to the Mesozoic genus *Nilssonia*, and cannot be classed as true Pterophyllums. Many of the preparations described were made by the late Prof. R. Zeiller, who, shortly before his death, kindly placed them at the disposal of the author.

The paper raised the question of the value of cuticle characters in the diagnosis and classification of fossil fronds.

Dr. D. H. Scott said the paper was of great interest to all fossil botanists. He wished to ask Dr. Thomas whether the cuticular structure of *Anomozamites* threw any light on the affinities of *Wielandiella*, a genus with a remarkable fructification and habit, and with the foliage of *Anomozamites*.

The Palæozoic Cycads, few in number, were of great importance as the precursors of the vast Cycadophytic Flora of the Mesozoic Age. Did their cuticular characters indicate an affinity with the Bennettitales or, rather, with the Cycadaceæ proper? He would like to appeal to Dr. Thomas on a question of Palæozoic Botany. They were in a great difficulty; the late Dr. Kidston, the highest authority, had cast grave doubts on the position of the great Tree Ferns of the Carboniferous, suspecting that they may all have been Pteridosperms. It was known that one of them, *Dicksonites Pluckeneti*, was a seed-bearing plant. Could Dr. Thomas compare the cuticular structure of *Dicksonites* with that of the remaining "Marattiaceæ," such as *Scolecopteris* or *Asterotheca*? In the absence, as yet, of any anatomical knowledge of *Dicksonites*, such a comparison might well be of considerable value.

Prof. F. E. Weiss stated that he possessed some fronds of *Pterophyllum*, from Basle, which showed a considerable amount of variation in their shape, and he was interested to hear that from the structure of their cuticle they belonged probably to the same species. In the study of both fossil and recent plants important information can be obtained from the careful study of cuticular and stomatal structure.

Mr. W. N. Edwards asked if cuticle structure furnished specific characters only in Gymnosperms and Cycads, and if Dr. Thomas had examined the structure of the cuticle from other parts than the fronds.

Mr. J. Ramsbottom suggested that the problematical "epiphytic organisms," shown in one of the slides, were Microthyriaceous fungi allied to *Asterina*. About half a dozen of the Asterineæ occur in Europe at the present day, but the group is widely distributed in those regions of the Tropics where the annual rainfall is more than a metre.

In replying to the remarks on his paper, Dr. Thomas said that *Anomozamites* showed typical Bennettitalean characters and came very near to the form *Tæniopteris vittata*, which had been shown to be probably the leaf of the plant called *Williamsoniella*. There was no difficulty in separating the Jurassic Cycadophyta from the contemporary ferns, which had very delicate cuticles only.

He thought it was very probable that the cuticle characters would afford a means of deciding whether the uncertain fern-like fronds of the Carboniferous rocks were Ferns or Pteridosperms.

With regard to the questions put by Mr. Edwards, he could say only that he thought the different species of Cycadophyta could be distinguished by their cuticles, and understood that Dr. Florin,

of Stockholm, had found the same to be true also of Conifers. Only a few observations had been made on the cuticles of parts other than the leaf lamina.

The question of the problems of nomenclature raised by the identification of species by their cuticles alone was a large one and would need careful consideration. Often, however, the recognition of specific differences by cuticle study led to the appreciation of small but important differences in external form.

Prof. W. M. Tattersall (Visitor) read his paper, illustrated with lantern-slides, on *Asellus cavaticus* Schiodte, a blind Isopod new to the British Fauna, from a well in Hampshire. The following is an abstract of his paper:—

In 1925 and 1926 Miss Lucas discovered specimens of a blind *Asellus* in a well at Ringwood, Hampshire, which the author identifies with *Asellus cavaticus* Schiödte. It is new to the British fauna, but is rather widely distributed in subterranean waters in France, Germany, and possibly Switzerland. A brief history of the species with its synonyms was given, from its discovery in 1849 by Fuhlrott in Germany. The species is figured for the first time and redescribed in the light of recent work. Its affinities with the *A. meridianus* group of species were confirmed and its relations with other species briefly discussed. It is a typical cavernicolous species without eyes and without any trace of pigment. It must have been isolated in England at least since early Tertiary times, yet has apparently remained unchanged during that long period of isolation, probably as the result of the very uniform conditions obtaining in underground waters. The species of the *meridianus* group are widely distributed throughout Southern Europe, North Africa, and Palestine, very largely in association with early Tertiary rocks. The frequency of this association is significant, particularly in the underground species, and is once again exemplified in this new British record.

The President expressed his interest in Prof. Tattersall's conclusion that the distribution of *Asellus* was associated with the occurrence of Tertiary geological formations.

Dr. W. T. Calman referred to the exceptional interest of the problems concerned with the life of cavernicolous animals.

Mr. C. C. A. Monro gave a synopsis of a paper by Mr. A. H. Clark, of the American National Museum, on some Recent Crinoids in the collection of the British Museum.

The paper dealt with fifty-five species of Crinoids, nine of which are new. One of these new species is regarded as the representative of a new genus. More than half of the species, including all the new forms, were secured by the cable-repair ships of the Eastern and Associated Telegraph Company in the

Malayan region, among the lesser Sunda Islands and the Seychelles, off the East Coast of Africa, and in the West Indies. The collection also includes several species obtained by Prof. J. Stanley Gardiner in the Maldives and by Dr. Cyril Crossland at Zanzibar.

In commenting on the paper he had read, Mr. Monro stated that he found it difficult to accept as valid the large number of contrasting pairs of characters, one primitive and the other specialised, which the author of the paper claimed to have recognized, in the collection studied.

Mr. G. C. Robson referred to the influence of depth of habitat on the occurrence of primitive and specialized characters in the group.

Mr. R. H. Burne suggested that the attitude of the resting Crinoid was more suited to receiving nourishment passively from the rain of dead plankton than actively from the living plankton.

Dr. W. T. Calman communicated a short paper by Dr. C. A. Nilsson-Cantell on new and interesting species of *Scalpellum* from a telegraph cable near the coast of North Chile.

The paper discussed four species (two of them new) of barnacles of the genus *Scalpellum* obtained from a telegraph cable at a depth of 343–400 fathoms off the coast of Chile. Some post-larval stages of one of the species described show remarkable variations in the development of the valves of the shell.

Dr. Calman attributed the comparative richness of the forms of life found adhering to cables to the fact that cables, when they did not sink into the soft bottom ooze, afforded most welcome resting-places to sedentary creatures in the depths.

Dr. G. P. Bidder said that, although exploration of the land surface approximated a dull completeness, it would be a century, or centuries, before we ceased to find new and unexpected genera from the deep sea. Of sea-bottom below 1000 fathoms, the proportion hitherto scraped by the dredge amounted to a ludicrously small decimal of one per cent. The known deep-sea sponges were only fragmentary instalments of the unknown population.

29th November, 1928.

Sir Sidney F. Harmer, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous Meeting, held on Thursday the 15th November, 1928, having been circulated, were taken as read and confirmed.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

Malcolm Arthur Smith was admitted a Fellow.

Certificates of recommendation of the following candidates for Fellowship were read for the second time:—Miss Anna McClean Bidder, Miss Susan Finnegan, Miss Anna Birchall Hastings, Stanley Wells Kemp, Miss Eileen Reed, and William Keble Martin.

The Director of the Royal Botanic Gardens, Kew, showed a small collection of minute succulent plants, which had been sent over from South Africa by Mr. J. Hutchinson, F.L.S., who is now on a botanical expedition there.

The species represented were *Conophytum Comptonii*, *Anacampseros Comptonii*, and *Crassula Comptonii*, and were originally found by Prof. Compton near the top of Vanrhyns Pass in a small hard pan of rock. In addition to these three species, a specimen of a new species of *Lithops* growing in shales, a *Crassula* near *C. columnaris*, and a specimen of *Mesembryanthemum*, probably *testiculare*, growing amongst blocks of white rock, which they closely resemble, were also exhibited. The *Crassula* is probably the smallest species of the genus. The *Lithops* was found near Koup Station, the only locality known for this plant, which grows wedged tightly between pieces of inverted shale.

The specimens had been potted at Kew with stones and shale sent over with the specimens from South Africa, and the natural conditions had been so well reproduced, that it was difficult to detect the plants from the stones.

Mr. T. A. Sprague gave an account, illustrated with lantern-slides, of the results of his study, in conjunction with Mr. E. Nelmes, of the Herbal of Leonhard Fuchs.

The paper on which the account was based, gives identifications of the 511 plants figured, prefaced by a general account of the Herbal. This is divided into chapters corresponding with those of Dioscorides, and arranged according to the Greek alphabet, the chief authorities cited being Dioscorides, Galen, and Pliny. The classification is mainly (1) pharmaceutical and economic, but sometimes (2) philological: thus (1) *Campanula Rapunculus* L. is classed with the Swede and the Beet, because it has an edible root, and is widely separated in consequence from *C. Trachelium* L., which was used as a remedy for ulcers; and (2) *Momordica Balsamina* L. and *Impatiens Balsamina* L. are placed in the same chapter (genus) because the former was called *Balsamina* and the latter *Balsaminum*.

The nomenclature adopted on the plates is at first sight extremely puzzling, and cannot be understood without reference to the text. It may be unitary, binary, ternary or rarely quaternary, and uninominal, binominal, trinominal or quadri-

nominal. But the nature of the nomenclature and its form do not necessarily correspond. Thus a trinominal designation, for example, may be either unitary, e. g. *Ephemerum non letale* (a monotypic genus), or binary, e. g. *Trifolium pratense purpureum* (a species of the genus *Trifolium pratense*), or ternary, e. g. *Bellis minor hortensis* (a subspecies or variety of the species *Bellis minor*). *Helleborus niger adulterinus sylvestris* is really a binary combination, the genus being *Helleborus niger adulterinus*.

Mr. C. E. Salmon asked if the illustrations in the Herbal were drawn in line to facilitate colouring of them by possessors of the Herbal; also whether the descriptions in the German edition of 1543 were more accurate than those in the earlier edition of 1542. He mentioned the existence of a copy of the 1542 edition in the library of Winchester Cathedral, which had been coloured and written up with English names by a contemporary botanist, probably one John Warner, who was Dean at that time.

The Botanical Secretary, commenting on the persistence of classical names, related that when he was at Mycenæ he had ascertained from a nomadic shepherd that the name 'heliotropion' was the folk-name for *Heliotropium europæum*.

He also exhibited, on behalf of Dr. R. T. Gunther, the second volume of a collection of coloured illustrations cut out of a copy of the 'Stirpium Historia' of Fuchs, and arranged according to the Linnæan system by R. Pulteney, author of the 'Life of Linnæus.' According to a note in this second volume, the two volumes were sold at Sotheby's in 1828, and passed into the library of Mr. Lee of Hartwell. Although two volumes were in existence in 1828, the first volume had become separated from the second in 1876, when the late Dr. B. D. Jackson acquired the latter. If the whereabouts of the first volume be known to anyone, it would be desirable to make that information available as a matter of bibliographical interest.

Mr. A. J. Wilmott suggested that plant names persisted, although not published, through the continuous use of them by apothecaries.

The President described the study of the old herbals as a diversion in the pursuit of which botanists had an advantage over zoologists, who had little or no such corresponding literature to interest them. He supposed that the apparently inappropriate colour-indicating names sometimes applied to plants were due to the fact that the names were based on the appearance of the medicinal parts yielded by such plants and not on the colour of petals or such-like organs.

In reply, Mr. Sprague stated that there was no evidence to support the view that the illustrations to the Herbal were in outline merely to facilitate the colouring of them. Outline illustration was the fashion of the period. He had not yet studied the German edition in detail, but was of opinion that it showed no special superiority over the Latin edition. He supported the President's explanation of the occasional apparent discrepancy

between plant names indicating colour and the actual colour of floral organs, "black" merely meaning that the herbalist's preparation was dark as compared with that of the "white" variety.

Miss E. L. Stephens exhibited, with explanatory remarks, a large number of fine and interesting lantern-slides, coloured and uncoloured, illustrating the scenery, physiographical features, vegetation, and individual plants and animals characteristic of the Cape Peninsula.

In reply to questions by Dr. A. B. Rendle and Mr. T. W. Saxton, Miss Stephens stated that the Proteas were at their best in August, while bulbous species were in most profusion during September to November. There was as yet no explanation of the fact that a greater abundance and variety of forms of life were to be found in the sheets of water that dried up during the dry season than in the lakes that persisted throughout the year.

13th December, 1928.

Sir Sidney F. Harmer, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous Meeting, held on Thursday the 29th November, 1928, having been circulated, were taken as read and confirmed.

The following candidates were balloted for and elected as Fellows:—Russell Solomon, M.Sc., Mrs. Lucy Howland, M.Sc., Frederick Sydney Banfield, John Frederick Vicars Phillips, Frederick Whalley Sansome, B.Sc., Ph.D., John Oliver Borley, O.B.E., M.A., Cecil Prescott Hurst, Miss Lilian Mary Joy, B.Sc., George Evelyn Hutchinson, M.A., George Stuart Carter, M.A., Ph.D., James Erik Hamilton, M.Sc., William Alexander Francis Balfour-Browne, M.A., F.R.S.E., George Olds Cooper, B.A., M.A., Ph.D., Miss Nora Cameron Rogers, Arthur Francis Bulmer Standfast, B.A., Miss Anna McClean Bidder, B.A., Miss Susan Finnegan, B.Sc., Miss Anna Birchall Hastings, B.A., Stanley Wells Kemp, Sc.D., Miss Eileen Reed, M.A., B.Sc., William Keble Martin, M.A.

A statement of the names of donors of gifts received since the previous Meeting was read and laid on the table.

Certificates of recommendation for election to Fellowship were read for the first time in favour of:—Timeri Murari, B.Sc., Edmund Arthur Robins, and Godfrey Michael Graham, M.A.

The following Fellows were admitted:—Sunder Lal Hora, Daphne Aubertin, and Cecil Prescott Hurst.

Mr. H. N. Dixon exhibited a coconut grown at Mbereshi in Northern Rhodesia, about 1000 miles from the nearest point on the coast and about 3500 feet above sea-level. The tree, with others, was grown from nuts brought from Dar-es-Salaam and planted in 1913. The trees produced fruit for the first time in 1927, and the specimen exhibited was the second fruit produced.

In reply to a remark by Mr. H. N. Ridley that the remains of old salt-lakes were found below the soil of a plantation of coconuts planted in South America very far from the coast, Mr. Dixon stated that salt had been added to the soil in which the African examples had been planted, but he was unaware that this had any influence on the growth of the plants.

Dr. A. W. Hill exhibited a series of lantern-slides illustrating the vegetation of the parts of Australia, Tasmania, and New Zealand which he had visited in the course of a recent official tour.

In reply to a question by Dr. Rushton Parker regarding the relative heights of Sequoia and Eucalyptus trees, Dr. Hill stated that the latter attained the greater height.

The President related his own experience of the wonderful powers of recovery of *Ramondia* from apparently fatal desiccation. He also enquired whether Dr. Hill could give any information regarding the continued existence or fate of "Pelorus Jack," the well-known dolphin that used to accompany ships passing between the two New Zealand islands, and on behalf of which a special enactment had been passed to ensure its preservation. Dr. Hill explained that as his sea-passages were always by night he had no opportunity of a personal introduction to "Pelorus Jack," and had not been informed as to his continued existence or otherwise. Dr. Rushton Parker stated that while he placed no reliance on the information, he had been informed that "Pelorus Jack" had been killed by a foreigner from North America.

Dr. S. L. Hora read a paper, illustrated with lantern-slides, on convergent and divergent evolution as exemplified by various animals which had been the subject of his study. The following is an abstract of his paper:—

Since Darwin's time our conception regarding the relative importance of the principles of divergence and convergence has undergone considerable change. Variations in organisms are the result of divergence. Convergence implies resemblances "which result from independent functional adaption to similar ends." Animals living under different conditions sometimes exhibit similar modifications; but on analysis these modifications are found to be responses to similar factors in the environments. This basic idea of convergence was illustrated by several instances of similar structures found in the inhabitants of torrential streams

and in the fauna of sluggish waters. Attention was also directed to the "Communal Convergence" with special reference to the body-form of insects inhabiting torrents. By referring to the differences in the nature of the ostia of certain sponges now living in muddy water and to the divergent modifications of the rays in the paired fins of the Homalopterid fishes, it was indicated how organisms living in the same environment and in response to the same element in the habitat are sometimes differently modified. It was concluded that environment is the supreme master of most of the changes in animal organization and that organic evolution is an index of the varied conditions under which life exists. Structures become moulded time and again, progressively or retrogressively, due to changes in the habits and habitats of organisms.

Dr. G. P. Bidder congratulated Dr. Hora on his clear exposition of the very interesting conclusions to which he had been led by prolonged work in the field. Fifty years ago Sir Ray Lankester made "Homoplasy" a prominent feature in his teaching, and it seemed desirable that those who, like Dr. Hora and the speaker, believed that convergence is caused by the similar moulding of different races by their environment, should speak of homoplasy or homoplastic convergence, thereby distinguishing the view adopted from that of the writers who appear to regard "convergence" as a mystic property of species.

Mr. J. T. Cunningham paid tribute to the great interest of Dr. Hora's original observation in the field on adaptations of organisms. There were, however, two points of special interest to biologists which Dr. Hora had not considered. The first was the limits of adaptation—whether some characters were unrelated to adaptation. The second point was how adaptation was produced—whether by selection of mutations originally independent of external conditions, or by direct influence of function or conditions transmitted to subsequent generations.

In reply to Dr. Bidder's suggestion about the use of the term "Homoplasy" instead of "Convergence," Dr. Hora stated that "Divergence of Character" and "Convergence of Character" are two principles clearly enunciated by Darwin in his 'Origin of Species,' and in the paper the terms were used in the same broad sense.

In reply to Mr. Cunningham, it was pointed out that the so-called non-adapted characters are considered to be useless only so long as no apparent utility can be ascribed to them. A thorough study of the bionomics of the organisms often shows that these very characters are of great functional value. As an illustration, reference was made to Mr. Cunningham's work on the fish *Zeugopterus* (1893–95), in which he showed the utility of the posterior parts of the fin-fringes for the purpose of adhesion, but was unable to find any use for the subcaudal prolongations. Among the hill-stream fauna several diverse animals possess a similar adhesive apparatus, and from analogy it would appear that the subcaudal

prolongations help in fixation by reducing the area in which a current of higher velocity is set up. The object of the paper was to show, from a purely ecological point of view, how through Divergence and Convergence of Characters animals become adapted to their surroundings; the causes of variations and the mode of their transmission were not considered.

3rd January, 1929.

Sir Sidney F. Harmer, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous meeting, held on Thursday the 13th December, 1928, having been circulated, were taken as read and confirmed.

A statement of the names of donors of gifts received since the previous meeting was read and laid on the table.

The following Fellows signed the Obligation in the Book of the Charter and Bye-Laws and were admitted:—Lilian Mary Joy, Lucy J. Howland, William Thomas Mathias, and George Stuart Carter.

Prof. C. E. Moss gave an account, illustrated with lantern-slides, of a new genus of Hydrocharitaceæ from tropical Africa. The following is an abstract of his paper:—

The freshwater plant which formed the subject of this communication was first brought to the author's notice by Miss M. E. Blenkiron (now Mrs. Blenkiron-Young), who collected specimens on the 9th July, 1927, in the river Zambesi, at its confluence with the river Linyanti, at Kazangula, above Livingstone, in Rhodesia. The plant was growing, staminate plants here and pistillate plants there, on the water-margin of a reed swamp in which crocodiles lurk, in water about three metres deep. Apart from the flowers, the whole plant was submerged. A few days later, Mr. and Mrs. G. E. Hutchinson independently collected the same species at Katombora, between Kazangula and Livingstone, again in the river Zambesi. About a month or so later, Mr. O. K. Berrell, the then inhabitant of Kazangula, sent specimens, in weak formalin, from the first locality. The specimens in the author's herbarium are Nos. 14819, 14861, and 15604 respectively.

On examination, it became evident that the specimens belonged to the same species and to the family Hydrocharitaceæ; but it was equally obvious that there was no genus in Bentham and Hooker's 'Genera Plantarum' or in Engler & Prantl's 'Pflanzenfamilien' which could receive the species. The nearest genera

were *Blyxa* and *Hydrotrophus*. These two genera, however, have extremely narrow or even filamentous petals: they have only three to nine stamens; and staminodes are absent, or nearly absent, from the pistillate flower of *Blyxa* and the monoclinous flower of *Hydrotrophus*. In the plant under examination (omitting, for the present, some more obscure characters) the petals are broad: the stamens number twelve, and are of four different sizes: six staminodes, three large filament-like ones and three small scale-like ones, occur in the pistillate flower. Moreover, the new plant is remarkable by its elongate and ligulate leaves, its elongate and terete peduncles, and its cylindrical and monophyllous spathes, all covered with soft conical projections.

The author confessed he was unable to divine what purpose these soft projections served.

Vallisneria is another allied genus; but here the corolla is absent or nearly absent, and the flowers are monoclinous. *Enhydrias*, *Maidenia*, and *Lagarosiphon* are also allied as regards floral structure, but differ markedly in having elongated leafy stems. *Hydrilla* and *Helodea*, through the last three genera, are also related, but rather distantly.

Specimens of the author's No. 14819 were forwarded to Mr. N. E. Brown for comparison with allied specimens which might be at Kew, along with the suggestion that those sent perhaps belonged to an undescribed genus. Mr. Brown agreed that the suggestion was possibly correct, but also identified the plant as *Boottia muricata* C. H. Wright.

It was clear to the author that the specimens did not belong to the genus *Boottia*, as Bentham and Hooker (Gen. Pl.), and Ascherson and Gürcke (in Engler's 'Pflanzenfamilien') place *Boottia* among those genera which are characterized by six or more placentæ projecting strongly into the cavity of the ovary; whereas the specimens in question have, like *Blyxa* and the other allied genera, only three placentæ which scarcely project at all into the ovary cavity.

No further progress could be made in South Africa by the author. Recently he arrived on a visit to Kew and continued his examination, especially regarding some genera described fairly recently, and regarding certain specimens which were obviously involved.

It was then apparent that Mr. Brown's determination was correct. The plants are, indeed, identical with the type-specimen of *Boottia muricata* Wright. Some emendations of Mr. Wright's descriptions (in Fl. Trop. Afr. and in Hooker's Icon Pl.) are, however, necessary, and also of the figure in the latter work. The author's specimens are also almost identical with a specimen of the type-gathering of *Boottia Aschersoniana* Gürcke, from South-west Africa, and with specimens collected by Gossweiler (Nos. 2091 and 3966 in Herb. Mus. Brit.) in Angola. These specimens also were referred by the author to his new genus. Mr. Wright's specimens came from Rhodesia and Bechuanaland.

From the latter, however, Allen No. 329, from which the leaf was drawn in the figure mentioned, must be removed. Thus, the new genus, consisting at present of two closely-allied species, occurs in Central Africa, from the Atlantic to the Indian Ocean, between the Equator and the Tropic of Capricorn, and in the more northerly portion of this area. "*Boottia muricata*" Wright occupies the eastern and central portions of this area, and "*Boottia Aschersoniana*" Gürcke the western.

Of the freshwater Hydrocharitaceous genera, which have six or more strongly projecting placentæ, the nearest one to the new genus is *Stratiotes*, and after that come *Boottia*, *Xystrolobus*, *Ottelia*, and *Oligolobos*.

The author thought it was not difficult to imagine some pre-Hydrocharitaceous plant giving rise on the one hand to *Stratiotes* and its allies, and on the other hand to the new genus and its allies.

A new classification of the Hydrocharitaceæ, bringing in the genera discovered since the publication of the Pflanzenfamilien, was briefly discussed by the author.

Dr. A. B. Rendle congratulated Professor Moss on having had the opportunity of examining the plants in a condition approximating to the living state, and thus avoiding the pitfalls that await the worker with herbarium species. He asked Professor Moss whether he had any idea as to the function of the warty projections on the peduncles, which recalled those on other aquatic plants such as *Naias marina* L., to which it is difficult to assign any function.

Mr. H. N. Ridley referred to the richness of Africa in aquatic plants and suggested that Professor Moss's new genus might be intermediate between *Vallisneria* and *Ottelia*.

Sir David Prain mentioned as an illustration of the difficulties of identification in these aquatic plants that many years ago Hamilton sent to the first President of the Society a plant under the name of *Vallisneria alternifolia* Roxb., which afterwards was transferred to another genus.

In his reply Professor Moss expressed his inability to agree with the suggestions that the new genus was intermediate either between *Bootia* and *Blyxa* or between *Vallisneria* and *Ottelia*. He mentioned that the warty projections were in origin cortical on the peduncles and mesophyllar on the leaves. He was unable to throw any light on their function.

A paper by Dr. G. S. Carter and Mr. L. C. Beadle on the fauna of the swamps of the Paraguayan Chaco in relation to its environment, treating of the physico-chemical conditions of the environment, was read in title. The following is an abstract of the paper:—

This paper contains the first part of the results of an investigation of the conditions of life in the tropical swamps of the

Paraguayan Chaco. These swamps cover large areas of the plains to the west of the Paraguay River on the latitude of the southern tropic. The investigations were made on the swamps in the neighbourhood of the station of the South American Mission Society at Makthlawaiya (58° 19′ W., 23° 25′ S.).

A general description of the climate, vegetation, and geology of these plains is given. The swamps are shallow, frequently dry, and are filled with much aerial vegetation in all parts.

During eight months, (Oct. 1926–June 1927), observations were made at regular intervals of several characteristics of the water in the swamps. These included the temperature, pH-, oxygen-, bicarbonate-, phosphate-, and carbon-dioxide-contents. For comparison with these observations certain other waters in the same district were also investigated.

The most striking results of the observations made on the water of the swamps were the following:—

(1) The high temperature which the surface-layers of the water were sometimes found to reach (42° C.).

(2) The large quantities of phosphates which were always present (up to 10 mgrs. per litre).

(3) The low tension of dissolved oxygen. Not more than 2–3 c.c. per litre was ever found in the surface-layers of the water, and frequently even the surface-layers contained less than ·5 c.c. per litre. Below the upper 10–15 cm. of the water there was hardly ever more than ·2 c.c. per litre during the hot weather.

The cause of this low oxygen-content is believed to be complex. It is thought to be due partly to the poverty of the aquatic flora, partly to the great activity of decay at the high temperature, and partly to the absence of convection-currents caused by the cooling of the surface-layers at night. In temperate countries, where the cooler nights probably always set up these currents, they seem to be of great value to the fauna in keeping up the oxygen-content of the lower layers of the water. It is suggested that conditions similar to those found in the swamps of the Chaco are widespread in similar waters in the Tropics.

Observations on the behaviour and distribution of the fauna showed that of these conditions the shortage of dissolved oxygen in the water was of greatest bionomic importance. The variations of the phosphate-content appeared to have no influence on the distribution of the fauna, and the temperature, although it was sometimes very close to the bionomic limit, seemed never to exceed it. Further observations on the behaviour and adaptations of the fauna are reserved for a later paper.

A report by Mr. R. Gurney on the Branchiopoda collected by Dr. G. S. Carter and Mr. L. C. Beadle during their expedition to

Brazil and Paraguay in 1926–27 was read in title. The following is an abstract of the paper :—

Dr. Carter's collections include five species, of which three appear to be undescribed. Four of them are Conchostraca, and include the remarkable *Cyclestheria hislopi*, which is found also in Africa, India, Ceylon, and Australia. A new species of *Dendrocephalus* is an Anostracan with extraordinary branching "frontal processes" from the basal joints of the 2nd antennæ, which fuse together in development. There is a new species of *Eulimnadia*, and another specimen has been placed in a new genus because in the male the 2nd legs are peculiarly modified and asymmetrical.

A report by Mr. E. Meyrick, F.R.S., on the Microlepidoptera of the same expedition was also read in title. The following is an abstract of the report :—

The nature of the region is probably not very favourable to Microlepidoptera. The number of species in identifiable condition is 32 ; of these, two genera and 22 species are described as new. Of the remainder, three are horticultural pests introduced with their food-plants, one a widely-spread American insect, two are found also in the Argentine, and four in the Amazon valley. The new species are generally of Guiana and Amazon types.

Dr. G. S. Carter read notes, illustrated with lantern-slides, of the observations made by Mr. L. C. Beadle and himself on the habits and development of *Lepidosiren paradoxa*. Dr. Carter stated that the burrow to which the fish retires during dry weather had been further investigated, and he emphasised the importance to the fish of the subsoil of clay, which occurs everywhere in the parts of the Paraguayan Chaco inhabited by it. Where this clay is present, water is preserved in the burrow, and this is essential to the life of the fish in keeping its skin moist. Probably the cocoon of *Protopterus* serves the same purpose.

Oxygen is normally absent from the water surrounding the nest of the *Lepidosiren*, and the manner in which the respiratory needs of the eggs and young larvæ are satisfied was discussed.

Several observations on the developing larvæ were given, and experiments were described in which it was shown that the normal rhythm of the contraction of the pigment cells of the skin at dusk, and their expansion at dawn, is preserved for some days when the larvæ are kept in the dark continuously.

The President referred to the exceptional interest of *Lepidosiren* and to the importance of the Dipnoi as forming a link between the Fishes and the Amphibia.

Mr. J. T. Cunningham explained that the suggestion which had been made by him in a semi-popular publication, that the pelvic filaments of *Lepidosiren* gave out oxygen for the benefit of the eggs and larvæ, had not been based on any researches of his own,

but on the fact that the filaments were restricted to the male in the breeding-season, when it was confined with the eggs and larvæ in a narrow burrow. He asked for information regarding the conditions of reproduction in *Symbranchus* and how the eggs and young of this air-breathing fish were supplied with oxygen.

Mr. R. H. Burne asked how the fish managed to burrow through the clay.

Dr. Carter, in his reply, stated that he had no evidence of how the young of *Symbranchus* were supplied with oxygen. It was fairly easy for the fish to penetrate the clay in making its burrow, as at the season when the burrows were formed the clay was plastic.

Lt.-Col. J. Stephenson gave an account of the Oligochæta collected by Dr. G. S. Carter and Mr. L. C. Beadle on the expedition already mentioned. The following is an abstract of his paper:—

Oligochæta have been collected from the northern and more remote part of Paraguay only twice previously (Kerr; des Arts), and then only in small numbers; hence the present collection contains a large proportion of new species (one new species of *Pristina* (Naididæ), three of *Aulophorus* (Naididæ), one of *Limnodrilus* (Tubificidæ), three of *Kerria* (Ocnerodrilinæ), one of *Diachæta* (Glossoscolecinæ). Limicoline forms are in the majority.

A considerable part of the interest of the present collection lies in considerations of geographical distribution. *Æolosoma* (two species, indeterminable) and the common species of Naididæ (seven species, of which four are new) are easily transferred, and are probably cosmopolitan; but this scarcely explains the prevalence of *Aulophorus* (four species) and the absence of the related (and elsewhere common) *Dero*. The two species of *Nais* in the collection are found also in India—one only in India, the other in Zanzibar as well. A single species of Tubificid (a *Limnodrilus*, new) is remarkable, since the family belongs almost exclusively to the Northern Hemisphere (only 12 species from south of the Equator, and only one previously from South America). *Kerria*, the typical Megadriline of the region, first described from a neighbouring locality, is represented by three species, all new. There is a single species of *Diachæta*, new, and interesting, since the genus has been known hitherto only from the West Indies, 2000 miles away.

The single species of *Drilocrius* is probably new, but no mature specimens were found in any of the three batches. Sexual maturity is probably limited to some particular season of the year, perhaps quite a short one, as in other Oligochæta which inhabit marshes and swamps (*Criodrilus*; *Alma*).

The occurrence of a relatively large number of new species of *Aulophorus* furnishes the occasion for some remarks on the genus,

and a key of all the species is given. Two forms of calciferous glands (œsophageal pouches) which occur in the present species of the genus *Kerria* are described. The paper concludes with systematic descriptions of the several species.

Dr. W. A. Cunnington read a short paper, illustrated with lantern-slides, on the Argulidæ collected on the expedition. He mentioned that the Argulidæ collected by Dr. Carter belong to the genera *Dolops* and *Argulus*. The two species of *Dolops*—*Dolops striata* (Bouvier) and *Dolops geayi* (Bouvier)—were of interest, as certain specimens were larger than any hitherto recorded. The single species of *Argulus* appeared to be new to science.

Mr. H. W. Parker gave a brief account of the Amphibia and Reptilia of the expedition illustrated with a lantern-slide of the tadpoles mentioned below. He stated that in addition to specimens of an undescribed snake and other specimens which assist in determining the true status of a lizard and a frog recorded from the same general region, Dr. Carter's collections from the Paraguayan Chaco contained two tadpoles and a half-grown example of the frog *Ceratophrys lævis* (Budgett). The tadpoles, hitherto undescribed, have mouth-parts of a kind unique amongst the Salientia, and, as their food is exactly similar to that of some other species of *Ceratophrys*, this remarkable specialisation suggests that *lævis* is not closely related genetically to the other members of the genus in which it is at present included.

Owing to lack of time, there were no discussions on the last three papers.

17th January, 1929.

Sir Sidney F. Harmer, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous meeting, held on Thursday the 3rd January, 1929, having been circulated, were taken as read and confirmed.

A statement of the names of donors of gifts received since the previous meeting was read and laid on the table.

The following Fellows signed the Obligation in the Book of the Charter and Bye-Laws and were admitted:—Frederick Whalley Sansome and Edith Layard Stephens.

Dr. A. B. Rendle exhibited on behalf of Miss M. Egremont, who was present, about a score of pastel-drawings of West Australian plants.

Dr. Hugh Scott, in the absence of Dr. G. Enderlein, gave an exposition of the paper by the latter (presented by Prof. J. Stanley Gardiner), "Die Copeognathen-Fauna der Seychellen," of which the following is an abstract:—

No member of the Order Copeognatha (or Psocoptera, the 'Booklice' and their allies) had been recorded before from any of these islands. Particular attention was devoted to them in the Seychelles in 1908, and forty-seven species, belonging to twenty-seven genera, were collected. Six families are represented, and the scaly-winged forms (Lepidopsocidæ) account for more than half the species. Their wings are clothed with scales, and their colours and patterns vie in beauty with those of Microlepidoptera. The Lepidopsocidæ are feebly represented in Northern latitudes, but numerous in some parts of the Tropics. In 1906 an important work by the same author on the Copeognatha of Ceylon appeared, the wings of the scaly forms being illustrated by coloured plates from the fine drawings of Herr Alex. Reichert. This artist has now made coloured figures of the Seychelles species.

These minute insects need very careful treatment in the field. They are soft and delicate, and in fluid preservatives the scales come off. Therefore the specimens, as soon as killed, were mounted on the points of the finest pure-silver pins, the blunt ends of which were then inserted in cork stages. The abundance of Copeognatha was a feature of insect-life in the Seychelles. They were collected mainly by sweeping and beating foliage in the native forests at 1000–2000 feet above sea-level, but some were taken also among non-endemic vegetation at lower levels. Certain species seemed peculiar in their habits: *e.g.*, one was beaten only from a house-thatch made of freshly-cut palm-leaves, and another was found only between leaves of native palms and *Pandanus*.

Eight of the twenty-seven genera, and thirty-eight of the forty-seven species, are new to science. Of the nine species previously known, one is East African, one from Madagascar, one from Mauritius, three from the Comoros, and three are Oriental. Of these last, two have been recorded from Singapore and one from Ceylon; the latter was plentiful among fallen dead leaves of the Cinnamon-tree (*Cinnamomum zeylanicum*), with which it may have been introduced from the East. The author thinks that many of the species will be found in East Africa, and that Ethiopian elements predominate in the fauna. If this prove true, it will be the contrary condition to that existing among many groups of Seychelles insects, the relationships of which are largely Eastern.

Dr. Hugh Scott also gave, at the request of the author who was present, an account of a paper by Mr. S. Maulik (communicated by Prof. J. Stanley Gardiner) on "Chrysomelid

Coleoptera of the Subfamilies Eumolpinæ, Galerucinæ, and Halticinæ from the Seychelles and other islands of the Western Indian Ocean." The following is an abstract of the paper:—

Reports by the same author on two subfamilies of this great group of phytophagous beetles have already appeared. The present work deals with the remaining material of the family collected. There are sixteen species, fifteen being described as new, distributed among nine genera, four of which are new to science. Twelve species were found only in the Seychelles, one in both the Seychelles and Aldabra, two in Aldabra only, and one in the Farquhar Group. (i) The EUMOLPINÆ are represented by four genera and six species. From the Seychelles there are two species of *Rhyparida*, evidently endemic, from the highest zones of mountain-forest. This is a large genus, predominantly Austro-Malayan, but extending westwards to India and Ceylon. The Seychelles appear to be its westernmost outpost, as they are of many other Austro-Malayan and Indo-Malayan groups of insects. A second Seychelles genus, *Eka*, may be an introduced form. Three species, belonging to two Madagascan and African genera, were found in Aldabra. (ii) The GALERUCINÆ are represented in the Seychelles by a single Madagascan species, probably imported, though it has spread up into the native forests. (iii) Of the HALTICINÆ, or jumping "earth-fleas," there are four genera and nine species. In the Seychelles, the world-wide genus, *Chætocnema*, has three species, but two are exclusively from the high forests, and probably endemic. Two species of a new genus are also from the highest forest-clad peaks. Another new genus has three species, but these are not confined to the native forests: one occurs in Dennis Island, an outlying coral-island, and another in Aldabra, as well as the Seychelles. Lastly, the Farquhar Group, as far South as Aldabra, but a long way to the East, provides a new species of the world-wide genus, *Longitarsus*.

The material, as a whole, indicates an endemic element in the Seychelles fauna, with some Austro-Malayan affinities, also certain forms which have probably been imported; while the relationships of the Aldabran species are with Madagascar and Africa.

The President congratulated Dr. Scott on the interesting way in which he had brought these papers before the meeting.

Mr. S. Maulik, in answer to the President, said that he could add nothing to Dr. Scott's exposition.

Dr. A. B. RENDLE exhibited photographs of a remarkable West Australian Subterranean Orchid, which had recently been described by Dr. R. S. Rogers in a communication to the Royal Society of Western Australia.

The first specimen was turned up by the plough of an observant farmer in West Australia, and sent to the W.A. Agricultural Dept.; a notice in the press produced specimens

from two other localities. Dr. Rogers had kindly sent photographs and a short account of the plant, which Dr. Rendle was sure he would allow to be brought before the Linnean Society.

The plant consists of an underground rootless rhizome, which is "in symbiotic relationship with a fungus which closely invests the decayed roots of *Melaleuca uncinata* R. Br." It lives about a foot below the surface of the ground. The figures show short rhizomes with a terminal bud and slender lateral branches covered with scale-leaves. The flowers are borne in a dense head surrounded by an involucre of bracts terminating a slender scape, which grows from the rhizome apparently towards the surface of the soil. The inflorescence, which suggests the capitulum of a Composite, reaches about three inches across. The relatively large bracts surround numerous small flowers. The plant "when fresh is colourless," but "the capitulum acquires purplish-coloured tints on exposure to light." Dr. Rogers writes:—"The affinities of the plant are of course with the Gastrodiinæ, especially as regards its vegetative parts, but I feel that its inflorescence and certain other characters are too extraordinary to include it in that sub-tribe without unduly extending its limits. I have therefore thought it better to accommodate it in a new sub-tribe, which should be placed next to Gastrodiinæ."

Mr. H. N. Ridley compared this orchid to *Gastrodia malayana*, and suggested that the plant must at times come to the surface to be fertilized and to disperse its seeds, and that the coloration seemed to confirm this.

Lt.-Col. J. H. Tull Walsh considered that a flower which only just emerged from the ground might easily have escaped observation.

Mr. J. Ramsbottom pointed out the similarity of the subterranean orchid to the saprophytic prothalli of *Lycopodium*; and suggested that subterrranean plants are invariably associated with fungi, and that probably all plant saprophytes were symbiotic. Commenting on the similarities between the Australian orchid and the Japanese *Gastrodia elata*, of which lantern-slides had been shown, he stated that the fungus concerned in the second, *Armillaria mellea*, was well known for its destructive parasitism, being the most dangerous parasite in European forests. When it attacked the potato tuber it reduced it to a mush in a day or two, but when it attacked a similar-looking *Gastrodia* tuber, an association was set up without which the orchid was unable to flower.

Dr. G. P. Bidder pointed out that in ordinary English farming the plough would not uncover a plant the top of which was a foot below the surface.

Dr. A. W. Hill, on behalf of Prof. F. E. Lloyd, read a paper entitled "The Resistance of the Door of the *Utricularia* Trap to Water-pressure." From the work of previous authors it confirmed

by the author in conjunction with Mr. R. D. Gibbs), it appears that the trap is not only self-setting, but, if uninjured, remains permanently in the set condition. The set condition results from negative pressure of water within it; in this condition the sides of the trap are inbent and serve as relatively powerful springs to pull into the mouth of the trap a column of water if the door is released by pressure upon the trigger-hairs; the door, by virtue of its elasticity, due to the turgor of its cells, immediately springs back into position, and in the course of fifteen or more minutes the trap becomes reset.

The problem which remained to be solved was to explain the maintenance of the negative pressure within the trap if the set condition is permanent. This was usually considered to depend upon the efficiency of the door. A consideration of previous authors' suggestions and an examination of living material of *Utricularia minor* led to a different view of the door mechanism.

The door is a dome-shaped membrane, the shape and disposition of the cells being such, that, when the trap has been sprung, it springs back into its normal position, the hinge being attached in an approximately semicircular line about the opening. In the normal position the middle portion of the lower edge of the door comes to rest below the outer edge of the threshold. The whole of the middle portion of the door-edge thus finds a *ligne d'appui*, against which it rests firmly, and from which it can be dislodged only by an oblique upward movement of the thickened margin. This can be accomplished by pressure on the trigger-hairs which form, with the thickened lower part of the middle region of the door, a continuous lever, a very thin region just above their point of insertion serving as a fulcrum, in the fashion of a hinge. Since the extreme lateral extremities of the door-edge are attached to the wall at the *inner* edge of the threshold, it follows that the lateral portions of the door-edge must traverse the threshold obliquely, and as a matter of fact do not rest against any ridge or other resisting part as in the case of the middle portion. This, then, is the condition, and the difficulty of leakage remains, viz., that water could leak under the edges of the lateral stretches of the door, if not under the middle. Further examination led to the discovery that there is a mechanism quite apart from the door, but actually a part of the threshold, which is responsible for preventing leakage. The upper surface of the threshold is clothed with a peculiar epithelium of soft thick-walled compact cells forming a smooth mosaic (Goebel) in the verisimilitude of a door-mat. Across this the lower door-edge glides outwardly in resuming its normal position after the trap is sprung. But the cuticle of this tissue is exfoliated to form a membrane, which is stretched as a veil in front of the outer edge of the threshold and extends above its general level. This veil forms a sort of pocket in which the middle portion of the door-edge rests, effectively closing the rift between the door-edge and the edge of the threshold against which it rests. The veil is present throughout

the whole extent of the forward edge of the threshold, and lies against the lateral folds of the door also, in such a manner as to play the rôle of a weather-strip. The pressure of the outer water against this has only the effect of closing the rift more tightly. The veil is developed rather late and is of very delicate structure.

Prof. R. R. Gates said that Dr. C. L. Withycombe was one of the first to show that the *Utricularia* bladder acts as a real trap with a sensitive door (Journ. Linn. Soc. xlvi, 401). He describes the door as fitting into a groove at its base, but apparently makes no reference to the presence of the structure which Prof. Lloyd calls a veil. Perhaps species differ in this respect. Hegner, in the 'Biological Bulletin,' 1926, states that he estimated that about 150,000 entomostraca, as well as other organisms, were captured by a single plant.

Prof. C. E. Moss contrasted the two types of illustration shown on the screen: the earlier diagrammatic ones, and the later photographic ones which are much more useful to anyone desirous of ascertaining the precise working of such structures as the bladders of *Utricularia*.

Mr. D. J. Scourfield and Mr. R. Paulson also referred to Dr. Withycombe's experiments.

Mr. J. Ramsbottom stated that the work which he had communicated to the Society in 1923, on behalf of the late Dr. Withycombe, was begun when Withycombe was an undergraduate, and the preliminary results were published in 1916. After the full paper appeared, it was learned that T. Ekambaram had come to similar conclusions in a paper on the "Irritability of the Bladders in *Utricularia*," in the Agric. Journ. of India, in 1916.

31st January, 1929.

Sir Sidney F. Harmer, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous meeting, held on Thursday the 17th January, 1929, having been circulated, were taken as read and confirmed.

A statement of the names of donors of gifts received since the previous meeting was read and laid on the table.

The following Fellows signed the Obligation in the Book of the Charter and Bye-Laws and were admitted:—John Graham Kerr, William Keble Martin, Anna Birchall Hastings, and Susan Finnegan.

The President announced the death of Mrs. D. H. Scott, one of the early women-Fellows and wife of a Past-President of the

Society. A resolution was passed, all present standing, to convey through the President the sympathy of the Society with Dr. D. H. Scott in his bereavement.

The PRESIDENT declared two vacancies in the list of Foreign Members of the Society.

A mezzotint engraving of a portrait by James Northcote, R.A., of the Right Rev. Samuel Goodenough, Bishop of Carlisle from 1807 to 1827 and first Treasurer of the Society from 1788 to 1798, was exhibited.

Miss G. H. FAULKNER (Visitor) gave an account of her paper (communicated by Dr. W. T. CALMAN) on "The Anatomy and Histology of Bud-formation in the Serpulid, *Filograna implexa*."

Evidence leads to the conclusion that the genus *Salmacina* is synonymous with *Filograna*.

In the general account of *Filograna*, points of special interest arise in connection with: (1) the ciliary currents and their course in the tube; (2) the phases of the life-history and the sequence of these; (3) the musculature and the comparative simplicity of this; (4) the nephridia and their relationship with other Annelid nephridia; and (5) the blood-system and the evidence which this supplies in support of the theory of a blasto-cœlic origin of the Annelid blood-system.

The position of the plane of fission and the initial size of the bud are variable features; both are related to the length of abdomen of the stock.

Internal histological changes accompany the formation of the external form of the bud. These result in a complete histolysis of the original tissues of the bud-segments and their replacement by embryonic cells. The cells which are responsible for the replacement of the tissues are derived from neoblasts in the ventral body-wall. In the divisions of these neoblasts there is in every generation a complicated prophase, including both a synapsis and a syndesis phase.

The President remarked on the interest of Miss Faulkner's communication, and enquired (1) whether further information could be given as to the initial stages of the growth of the colony of *Filograna*; and (2) whether any evidence of asexual reproduction had been discovered in *Sabellaria*. The large colonies of this Polychæte might prove to be formed in this manner, in view of the association of a colonial habit with reproduction by fission, not only in *Filograna*, but also in *Phoronis*, a member of a very different group of Invertebrates.

Prof. W. Garstang endorsed the President's appreciation of Miss Faulkner's paper. He was himself particularly interested to compare the conditions described in *Filograna* with those encountered in the Tunicates. Could Miss Faulkner say when the neoblasts are first recognizable? Can they be already clearly distinguished in the early larval stages?

Prof. J. Graham Kerr referred to his good fortune in having sat in years long past under the President and first learned about Chætopoda from his admirable lectures. Miss Faulkner described an opaque appearance in the posterior segments of the bud. Is this opacity caused by moribund cells, or is it due to droplets of fat from digestion of the tissues by the phagocytes?

Dr. W. T. Calman considered that Miss Faulkner had been very modest in describing the colonies of *Filograna* as consisting of hundreds of individuals. He had seen a colony brought up from the North Sea on a fisherman's line which was a foot across, and must have contained many thousands of worms.

Miss Faulkner, in her reply, stated that the colonies of *Filograna* probably originate from a group of young individuals which settle close together at the end of their free-swimming existence.

She could give no information concerning budding in *Sabellaria*. In the formation of the thorax in the bud, two processes are concerned:—firstly, the formation of the two anterior setigerous segments in the ring of new embryonic tissue; secondly, the transformation of about six abdominal stock somites into bud thoracic somites.

Neoblasts are recognizable at any phase of the life-history. Malaquin has found them in the very young larvæ.

The opacity of the segments of the developing bud is probably due to the accumulation of fatty droplets in the phagocytes arising from the decomposition of the stock tissues.

Major R. W. G. Hingston gave a lecture, illustrated with lantern-slides, on the Natural History of the Oxford University Expedition to Greenland in 1928.

A brief outline was given of the work of the Oxford University Expedition to Greenland which selected Godthaab as the place for its investigations. Photographs were shown of the natural scenery of the district and of the area marked out for ecological survey. Animal life was very abundant, but the proportion of individuals to species was remarkably small. In summer the food-supply was so plentiful that there seemed to be a superfluity for all comers. Max Nicholson, the ornithologist to the Expedition, estimated that a pair of Greenland Wheatears captured 115,200 insects during the 12 days that they were feeding their young. The birds met with were more prolific than the corresponding species in temperate regions and their development was more rapid. The Passerine birds laid on an average two more eggs in each clutch, and the fledgling periods were reduced by five or six days. Referring to the colour of Arctic animals, it was stated that the reason why certain species, such as the Polar Wolf and Hare, do not change into a brown coat in summer, was because in summer, owing to the superfluity

of food, there was no struggle for existence in the ordinary sense, and therefore no necessity for such change to take place. Therefore the animals retained the coat which was of vital importance to them only in winter.

The President, while congratulating Major Hingston on the interest of his lecture and the excellence of his slides, expressed his difficulty in accepting in its entirety Major Hingston's view of the cause of the difference in the coloration of the animals of the area studied.

Mr. A. G. Lowndes confirmed Major Hingston's remarks regarding the wealth of life and the paucity of species.

Mr. R. H. Burne enquired if Major Hingston had noted the size of the animals in the area examined, as he had come across specially large fish and crustaceans from Greenland.

Dr. G. P. Bidder said that the nesting birds observed amounted to one pair per seven acres, which was a very much smaller population than would be found in England.

Lt.-Col. J. H. Tull Walsh referred to the colour of hares and stoats in England, and suggested that different degrees of inherited impressions of colder climates in the past, either in this country or in some other land from which they had emigrated, might account for the variation in winter changes of colour which had been important in more arctic climates than those where they are now presented.

Prof. J. Graham Kerr pointed out that two factors are at work: the ancestral tendency to brownness, and the more recently inherited winter change in Arctic species. In a boundary zone particular members of a fauna might not conform with the regular arrangement.

Mr. R. Paulson said that the paucity of species and abundance of individuals described by the zoologists are also found in the flora of Greenland. The conspicuous patches of white in some of the photographs of the Greenland landscape are sheets of the lichen *Cladonia sylvatica*.

Mr. A. R. S. Proctor asked if the *Salix* association was an open or closed one, and whether there were many annual species of plants.

Mr. A. G. Lowndes, in reply to Mr. Burne's question, said that the marine Entomostraca of Greenland are larger than in British waters, but not the freshwater species.

Major Hingston stated, in reply, that he did not feel qualified to express an opinion on botanical questions. It was hoped that Mr. Trapnell, the botanist to the Expedition, would make a statement to the Society at a later date. He met with no evidence of increase in size when comparing Greenland and European species. The profusion of bird-life was more evident on the bird-breeding rocks than on the small area they surveyed, but the numbers found breeding on that area brought out clearly the small proportion of species compared with the numbers of individuals.

14th February, 1929.

Sir Sidney F. Harmer, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous meeting, held on Thursday the 31st January, 1929, having been circulated, were taken as read and confirmed.

A statement of the names of donors of gifts received since the previous meeting was read and laid on the table.

The President intimated that the Hooker Lecture would be delivered by Dr. E. J. Allen, F.R.S., Director of the Marine Biological Laboratory, on the 14th March, 1929.

Mr. E. E. Edwards was unable to be present to give his paper entitled "On the Morphology of the Larva of *Dorcus parallelopipedus* L.," of which the following is an abstract:—

A description is given of the detailed morphology of the larva of *Dorcus parallelopipedus* together with the salient features exhibited by the digestive and nervous systems. Apart from other characters, the larva of *Dorcus* can be separated from those of other European genera of Lucanidæ by the form and arrangement of the tubercles composing the coxæ and trochanteric stridulatory areas.

In its internal anatomy it exhibits affinities with certain genera of Scarabæidæ in the presence of three series of cæcal diverticula of the alimentary canal. The great lateral pouch-like cæcum of the colon described in *Cetonia* and in the Coprinæ is represented in *Dorcus* by a general dilatation of that region of the gut, rather than by a lateral diverticulum. The Malpighian tubes were found to differ considerably from the early account given by Dufour (1842), in that the two tubes of a side form a complex loop, owing to their distal extremities being confluent instead of terminating independently as described by that observer. This condition is rare among insects, but is described by Bugnion (1920) in the Lampyridæ. The nervous system is of an exceptionally primitive character as in *Lucanus*, and does not exhibit the great concentration of the ganglia of the ventral nerve-cord prevalent in larvæ of the allied family Scarabæidæ.

Dr. W. T. Calman, in the absence of the Zoological Secretary, read a note by the latter on Mr. Edwards's paper, calling attention to the interest of the various stridulatory organs apparently found necessary to the long sexless lives of the larvæ of Lamellicorn beetles.

Mr. H. N. Dixon suggested that stridulation in the larva might serve as a warning amongst wood-boring larvæ of the same species not to encroach upon each other's burrows.

The President commented on the variety of ways in which stridulating organs had been evolved in Arthropods and on the absence, in many cases, of precise knowledge as to their function.

Dr. W. T. Calman mentioned that *Palinurus* in life stridulated when taken out of the water; but he could suggest no explanation of the purpose of stridulation in *Palinurus*. It was improbable that it had anything to do with warning off enemies, as he could not imagine that *Palinurus* had any enemies to warn off.

Mr. A. G. Lowndes recalled that the Cicadas, which stridulate so loudly, have been stated to be deaf.

Major S. S. Flower gave evidence that toads, which have also been stated to be deaf, are not so. He had kept a toad (*Bombina bombina*) in a room which was two rooms off from another room in which was a wireless set with a loud-speaker. When the striking of the hours by "Big Ben" was reproduced by the loud-speaker, the toad responded to the sound of each stroke of "Big Ben." Here, from the relative positions of the toad and the loud-speaker, there was no question of the communication of vibration as distinct from actual hearing. The responses of the toad to the sounds of "Big Ben" were not restricted to the breeding-season.

Mr. G. Taylor (Visitor), exhibited a series of lantern-slides of Scottish plants growing in their natural habitats.

It was pointed out that the alpines which are distributed over the range of Lawers-Caerlochan schist are sometimes peculiarly local. Slides of many of the more interesting of these plants were shown, and in addition, photographs of the rarer plants of the Pine-wood association and of rare Scottish plants with extremely limited distribution.

The President, Mr. T. B. Blow, Major S. S. Flower, and Dr. W. T. Calman commented upon the excellence of Mr. Taylor's photographs.

Prof. C. E. Moss asked whether *Primula stricta* occurred in Scotland, as he had found in Caithness a *Primula* which he had supposed might be that species.

Mr. A. J. Wilmott stated that he had cultivated both the Scottish *Primula* mentioned by Prof. Moss and the true Scandinavian *P. stricta*, and that they were not the same species.

Mr. E. G. Baker called attention to the disappearance of the rarer Scottish alpine plants, and mentioned as an example that he had failed to find *Eriophorum alpinum* in Scotland, although there were a large number of specimens in the British Museum collected in Scotland in bygone days. He invited suggestions for checking the further disappearance of species from Scotland.

Mr. G. W. E. Loder asked if *Eriocaulon septangulare* occurred on the Scottish mainland.

Mr. H. W. Pugsley endorsed Mr. Baker's remarks regarding the growing scarcity of the rarer Scottish alpine species, and suggested that the depredations of rock-garden collectors might have something to do with it. He commented on the unusually large size of the specimens of *Listera cordata* shown in one of Mr. Taylor's photographs, and on the unusual occurrence of *Lychnis alpina*—a species usually found in rocky situations—amidst grass.

Mr. H. N. Dixon stated that he had found *Lychnis alpina* both on rocks and in grassy places.

In his reply, Mr. Taylor, in reference to the questions regarding the relation of *Primula stricta* to *P. scotica*, stated that the latest view, as set forth by Prof. W. Wright Smith, was that *P. scotica* itself was merely a subspecies of *P. farinosa*. He also stated that *Eriocaulon septangulare* was not found on the Scottish mainland, but occurred on some of the islands, and was identical with the North American plant.

Mr. A. G. Lowndes exhibited a collection of lantern-slides of Edge Island, Spitsbergen, and read a paper on "Variation in Arctic Freshwater Entomostraca." The following is an abstract of the paper:—

Many species of freshwater Entomostraca are cosmopolitan in their distribution, and it has been possible to obtain in many cases the same species from the Tropics, the British Isles, and the Arctic, and an attempt has been made to correlate the difference in these three environments with variation shown by the separate species.

So far nothing has been found to show that such a correlation is possible, the same species showing the same amount of variation in each locality.

The voyage to Spitsbergen was made with the intention of collecting these species and examining them in the field. This absence of any change due to latitude, etc., is parallel with the absence of any change that can be correlated with a difference in hydrogen-ion concentration, etc., and many other factors usually considered under environment.

Is this absence of any modifying effect in environment peculiar to a few groups of freshwater Entomostraca, and in particular *Cyclops*, or are we dealing in *Cyclops* with a group of animals that has ceased to evolve?

The President referred to the facilities offered by the ephippian eggs of Cladocera to the distribution of species through the agency of Anatidæ or Wading Birds; and he suggested that new introductions effected in this manner might affect the variability of colonies which would otherwise be completely isolated. He enquired whether Mr. Lowndes had discovered any new facts with reference to the mode of distribution of Copepoda.

Dr. W. T. Calman testified to the value of Mr. Lowndes's investigations, and particularly his breeding experiments.

Prof. C. E. Moss described how the water depressions around Johannesburg, which became dried up during the dry season, were found to contain an abundance of Copepoda within a few days after rain had fallen, and asked for an explanation of how this sudden abundance could be explained without assuming that the Copepoda had remained in a dormant condition in the dried depressions.

Dr. J. M. Dalziel mentioned the existence of conditions in Northern Nigeria similar to those described by Professor Moss as occurring around Johannesburg. Although antelopes and wading birds might convey the crustacean eggs from perennial streams and rivers, he found it difficult to suppose that the eggs could be conveyed in this manner in such abundance as to fill the depressions in so short a time.

Mr. J. C. Shenstone suggested that the coats of the Cladocera eggs were sufficiently drought-resisting to enable them to withstand the dry period.

Mr. D. J. Scourfield said it was certainly a great puzzle how the species of *Cyclops*, without apparently showing any evidence of differentiation into local races, came to be so very widely distributed, seeing that, unlike some other Entomostraca, they did not produce any special eggs adapted for transport. However, there must be constant transport, either by birds or in some other way. A few days after rain, numerous specimens of *Cyclops* in all stages of growth could sometimes be found in ponds which had been apparently completely dried up. This seemed to show that some species could resist a considerable amount of desiccation, as was well known with some Rotifers and Tardigrades. Possibly, therefore, they might be transported in this state. He had had living specimens of *Cyclops* sent to him from Australia in sandy material which was only very slightly damp. One species at least had been found among the bottom sediment in a sort of cyst or cocoon. Such a condition would obviously facilitate distribution if it were at all general. As to *Cyclops strenuus* and *Daphnia pulex* from Edge Island, he would like to know whether the names were used in a restricted or a comprehensive sense, and if Mr. Lowndes had obtained any direct evidence about the mode of introduction of the Entomostraca into the seemingly unpromising pools, and about their food.

Major Hingston expressed his interest in the similarity of freshwater Entomostraca in high latitudes to those living in temperate latitudes compared with the amount of variation found in species of land animals according to the latitude of their distribution. He attributed the comparative lack of variation in water animals to the more or less uniform conditions prevailing in waters compared with varying land environments.

Mr. Ramsbottom suggested that because there were no obvious structures which appeared to be adaptations for withstanding unfavourable conditions, it did not follow that these did not exist.

He instanced the fact that spores of many fungi, though they had thin walls, were able to endure the temperature of liquid hydrogen, and many mycelia could exist in a dry condition for a number of years.

Mr. Lowndes, in his reply, suggested that, as ponds dry up gradually from the surface, the Entomostracan fauna might follow the retreating water and become encysted at some depth from the surface. This would explain the negative results of cultures of only the superficial dried layers. He stated that the eggs of *Cyclops* were not transferred on birds' legs, but that it was possible they could pass unharmed through the alimentary canal of birds. The position of Abyssinia, a regional island surrounded by deserts, presented a difficulty in the explanation of distribution of species of Entomostraca by transmission from other areas.

The Botanical Secretary summarized a paper by Prof. S. R. Bose on "The Biology of Wood-rotting Fungi." The paper deals with twelve species of woody fungi, including *Trametes gibbosa*, *Polyporus adustus*, *Polystictus velutinus*, and *Stereum hirsutum*. Introducing the paper, the speaker commented on the attention that had been paid recently to the cultivation of the larger fungi. This is usually much less successful than the culture of microfungi, where all groups except rusts and mildews may be said to have proved amenable to methods similar to those used in bacteriology. Whereas with microfungi it is usually possible to obtain normal fruit-bodies, these are comparatively rare in cultures of the larger fungi; when sporophores are obtained they are frequently abnormal.

The history of the cultivation of *Pholiota ægerita*, the common mushroom, *Polyporus tuberaster*, and the Japanese Shiitake was then commented on.

In his investigations Prof. Bose used Viala's culture medium, and sterilized wood blocks from which the air had been driven. Viala's medium consists of agar, sugar, wood-decoction, tartaric acid, and alcoholic tannin, the last having a considerable effect on the amount of growth obtained. For starting the cultures, either spores or pieces of tissue were used. Basidia are rarely to be found in the sporophores of Polypores, and it is suggested that a collapsed generation is not immediately succeeded by others as in Agarics.

Comparing growth on agar with that on wood blocks, the general result was that the life-cycle was shortened in the first and prolonged in the second. Sporophore formation occurred only in those cultures exposed to light, and was usually associated with poor vegetative growth. When fruit-bodies were formed, they usually occurred on the upper end of the slant towards the glass surface. This is probably related to moisture conditions and the check of vegetative growth.

28TH FEBRUARY, 1929.

Sir SIDNEY F. HARMER, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous meeting, held on Thursday the 14th February, 1929, having been circulated, were taken as read and confirmed.

A statement of the names of donors of gifts received since the previous meeting was read and laid on the table.

Certificates of recommendation of the following Candidates for election to Fellowship were read for the first time:—Herbert William Roy Bertrand, Edward Shefford Lyttel, Francis Gayner, William Alfred Cunnington, David Leslie Miln, Thomas Edward Miln, Herbert Gordon Garratt, Rakhal Das Bose, Kenneth Thomas St. George Cartwright.

Certificates of recommendation of the following candidates for election to Foreign Membership were read for the first time:—Theodor Mortensen, Bohumil Němec, Carl Hansen Ostenfeld.

Certificates of recommendation of the following Candidates for election to Associateship were read for the first time:—Hilderic Friend, Herbert Womersley.

Three papers were read dealing with the occurrence of natural hybrids in plants. The first paper was by Dr. A. W. HILL, C.M.G., F.R.S., on "Hybridization in the New Zealand Flora, with special reference to *Gaultheria*," of which the following is an abstract:—

Some 290 groups of wild hybrids have now been noted in New Zealand by Dr. L. Cockayne, F.R.S., Dr. H. H. Allan, and Messrs. G. Simpson and J. Scott Thomson. These belong to 42 families and 92 genera, and the majority consist of great polymorphic swarms. They are found abundantly in such genera as *Hebe*, *Celmisia*, *Olearia*, *Ranunculus*, *Myrtus*, *Aristotelia*, *Nothofagus*, *Phormium*, &c., and in the last genus open up questions of great economic importance. Species which cross are usually of the same growth-form, but this is not always so, for the tree-form hybridizes with the divaricating bush-form, as seen in *Plagianthus betulinus* × *divaricatus*, and the cupressoid *Hebe Astoni* with the leafy *H. buxifolia*, to cite but two examples.

Three species may sometimes hybridize and intergeneric hybrids are known. A specimen was shown of the hybrid *Leucogenes grandiceps* × *Raoulia bryoides*, found by Dr. H. H. Allan on Mount Hutt, in the Eastern Botanical District. Many of the hybrids are being cultivated in the gardens of the investigators in New Zealand. Dr. Allan has synthesized two hybrids, producing plants like those found in the wild state, and the seed from

assumed hybrids has produced a polymorphic progeny. This is also the case with the seed of hybrid Gaultherias, collected by the speaker in New Zealand, from which numerous seedlings have been raised at Kew.

Examples were shown of the hybrids resulting from the cross *Nothofagus cliffortioides* × *N. fusca*, and also a series of specimens of the hybrids *Myrtus bullata* × *M. obcordata* exhibiting every gradation from one species to the other. These had been collected by Dr. Cockayne in a remnant of forest by the Whangamoa River (Sounds-Nelson District), where they were also seen by the speaker, and at the edge of primæval forest near Fielding (North Island), by Dr. Allan. Living specimens from Kew were also shown, including *Myrtus Ralphii*, which is one of the midway hybrids of this swarm.

Life-size prints of the actual leaves taken from wild hybrid *Ranunculus* swarms, made by Messrs. G. Simpson and J. Scott Thomson, were also exhibited. These included a series of leaves of *Ranunculus Lyallii* × *Buchanani* var., Cheesman's *R. Matthewsii* having been described from similar hybrid material.

R. Simpsoni × *Buchanani* var., *Olearia ilicifolia* × *arborescens*, *O. macrodonta* Bak., was probably described from similar hybrid material, and *Aristotelia fruticosa* × *serrata*, of which *A. Colensoi* Hook. f. is one of a similar swarm.

A long series of *Gaultheria* hybrids, collected by the speaker on Rainbow Mountain and at Waimarino (North Island), and elsewhere, supplemented by specimens collected by Dr. Cockayne and others, was exhibited. This showed the gradual passage from *Gaultheria oppositifolia* to *G. antipoda*; from *G. oppositifolia* to *G. rupestris*, thence to *G. perplexa* and a series of hybrids between *G. perplexa* and *G. antipoda*, and *G. rupestris* and *G. antipoda*.

In connection with this remarkable series it should be noted that both *G. oppositifolia* and *G. rupestris* have a dry capsular fruit, and the calyx-segments do not become fleshy when the fruit ripens. In *G. antipoda*, however, the calyx becomes thick and fleshy as the seed ripens (though there is a well-marked form with a non-fleshy calyx), whilst in *G. perplexa* not only are the calyx-segments fleshy, but the fruit is a fleshy berry, exactly as in the genus *Pernettya*. This condition can be exactly matched in *Pernettya Pentlandii* from the Andes of South America.

In *G. oppositifolia* and *G. rupestris* the inflorescences are terminal panicles and the stems are practically glabrous. The polymorphic hybrids with *G. antipoda* have the stems covered with strigose hairs, alternate leaves, and the flower arrangement varies from axillary panicles or racemes to solitary flowers in the leaf axils. In some of the hybrids "fruits" were found with some of the calyx-segments fleshy and some dry in the same flower.

In places where *G. perplexa* and *G. antipoda* (? *G. depressa*) grow together, as at Waimarino, it is very rare to find either species in the pure state. When *G. rupestris* hybridizes with *G. antipoda* the progeny always shows a swollen fleshy calyx.

Most of the hybrid Gaultherias produce viable seeds. *Gaultheria fagifolia* Hook. f. is one of the hybrid swarms of either *G. oppositifolia* × *antipoda* or of *G. oppositifolia* × *rupestris*.

There is some evidence that the Gaultherias in Tasmania also hybridize, and *G. lanceolata* appears to be of hybrid origin.

The second paper was by Mr. E. M. Marsden-Jones and Dr. W. B. Turrill, on "Hybridization in certain Genera of the British Flora."

The results of genetical experiments and field investigations on certain British plant genera were outlined.

Crossing *Saxifraga rosacea* and *S. granulata*, a non-segregating F_2 generation was obtained with a chromosome-number double that of its parents. The special interest of this tetraploid was discussed.

Contrasts in the behaviour of *Silene* and *Centaurea* as found in the British flora were detailed. Wild hybrids between *S. maritima* and *S. vulgaris* are now known from several English counties, but crossing between these species has little or no effect on general populations. In *Centaurea*, on the contrary, hybridization has been rife in the southern and south-central counties of England, and has affected whole populations. Many of the so-called "species" of *Centaurea* included in recent British plant lists are of hybrid origin, as proved by synthetical and analytical experiments and by extensive field-work.

Attention was also called to the influence of hybridization on populations of *Geum* in this country.

The conclusion was drawn that hybridization has been an important factor in the origin of polymorphism in such genera as *Centaurea*, and that it has led to the making of what have been regarded as species by some taxonomists. On the other hand, in such genera as *Silene* interspecific hybridization is, at least now, of secondary importance, except for its genetical interest. It follows that, in the authors' opinion, hybridization is one, but only one, of the factors of organic evolution, using that term in its widest sense.

The third paper was by Prof. C. E. Moss, D.Sc., on "Some Natural Hybrids of *Clematis*, *Anemone*, and *Gerbera* from the Transvaal," of which the following is an abstract:—

Clematis brachiata Thunb. is a rather common plant around Johannesburg, and a local plant near Pretoria. The species has the habit of *C. vitalba* Linn.

Clematis Stanleyi Hook. is abundant in the same two districts, and in the same general type of habitat. The species, in the speaker's opinion, should be transferred to the genus *Anemone* Linn. The plant is about as tall as *A. japonica* Sieb. & Zucc. It is a very hairy plant, with no tendriloid petioles, with very narrow leaflets, and with solitary flowers. Its sepals are pinkish, imbricate, and very much larger than in *C. brachiata*.

In a few places near Johannesburg, numerous intermediates occur between the two very different species; and these intermediates connect up all the distinguishing characters of the two plants. The intergrading plants are absent from those situations where only one species occurs. The speaker had no doubt that the intermediates are fertile natural hybrids which cross with each other, and with the putative parents. It is fair to regard them as bigeneric hybrids. The figure in the 'Botanical Magazine' and the specimen from which it was drawn are better referred to as one of these hybrids than as *C. Stanleyi*. On the other hand, the original figure in the 'Icones Plantarum' and Burke and Zeyher's specimens from which it was drawn are better referred to *C. Stanleyi* itself.

Prof. Moss proposes to name the whole series of hybrids in honour of Miss G. Edwards, of Johannesburg, who first drew his attention to them.

A third species, *Clematis Oweniæ* Harvey, is abundant around Pretoria, and rare near Johannesburg. This species is very closely allied to *C. brachiata*, of which it has the habit. Sometimes *C. brachiata* and *C. Oweniæ* grow together, and then intergrading forms sometimes occur. These forms have not been found where only one of the species occurs; they are doubtless hybrids. The two species themselves are rather difficult to identify by the average botanist, and the natural crosses are also difficult to detect.

When all three species occur together, the hybrids become as complicated as the hybrids of *Primula* in the woods of Cambridgeshire, where the primrose, the cowslip, and the oxlip form a medley of abundant hybrids.

Gerbera discolor Sonder ex Harvey is common in marshes and by streams near Johannesburg and Pretoria. It is a herbaceous perennial, almost resembling *Leontodon hispidus* Linn. in habit and size. It has leaves which are green and glabrous above, and snow-white with felted hairs underneath. It has a head of yellow flowers and a brownish pappus.

G. plantaginea Harvey is also common in the same districts; but it occurs on the dry grass veldt. It is of the same size and habit as *G. discolor*; but its leaves, though hairy, are green on both sides. Its flowers are pink and white, as in *Bellis perennis* Linn., and its pappus is purple. The purple pappus is seen in the type-specimen, although the original description states otherwise.

Sometimes *G. discolor* and *G. plantaginea* occur cheek by jowl; and then a connecting series of very beautiful natural hybrids results.

This case also is complicated by the existence of a third species (*G.* sp. nov., aff. *G. viridifolia* Schultz), and again hybrids occur, which three species help to produce.

In the Woodbush Mountains of the Pietersburg district of the Transvaal, the speaker found some evidence of hybrids, in the

production of which at least four species of *Gerbera* seemed to join. The species are :—*G. Galpini* Klatt (grows in wet places, is glabrous, and has yellow flowers), *G. glandulosa* Dümmer (is very glandular, and has reddish flowers and a dark purple pappus), *G. plantaginea*, and *G.* sp. nov. (grows in dry places, has green and hairy leaves, and has yellow flowers). Further study is necessary in this locality later in the season when fruiting specimens will be available.

In both localities, which are very different climatically and floristically, there is a certain amount of evidence suggesting that *G. piloselloides* (Linn. fil.) Schultz plays a part in the production of the two hybrid sets.

A study of natural hybrids in such cases as the above has led the speaker to enunciate the following general conclusions :—

1. Bigeneric hybrids occur in nature, but, in the case of "good" genera, are probably rare. Bigeneric natural hybrids may be fertile.

2. Hybrids between well-defined species also occur in nature, but are not common. These hybrids are often fertile.

3. The above two classes of hybrids, when they do occur, are often very striking, and they can be easily detected.

4. Hybrids between closely-allied species are abundant in nature, and are usually fertile.

5. Hybrids of the last class are rarely striking, and are usually difficult to detect.

6. The more closely allied species are, the more difficult it is to detect their hybrid progeny.

7. There is no theoretical limit to the number of putative parents which may take part in the formation of natural hybrids in a given locality.

8. The more species taking part in the formation of a medley of natural hybrids, the more debatable becomes any determination of the possible parent species of any given specimen.

9. It is extremely unusual to meet with natural hybrids growing a considerable distance away from the putative parents.

10. It is possible to be quite certain of the existence of natural hybrids, even in the absence of actual experiments.

11. An old view that two "species," when linked up by intermediates, really constitute only one variable "species" is not of general application. The theory cannot be applied with certainty in any particular case until it is known that the intermediates are due to "real" variation or are a result of hybridization.

12. The speaker has come across no case of natural hybrids which has led him to suppose that natural hybrids may give rise to species.

The President expressed the hearty thanks of the Society to the speakers for their interesting papers. He stated that there

was much less evidence of the occurrence of natural hybrids in animals than in plants, and he appealed to Mr. Hinton as to whether he was aware of any cases of so-called species among the Mammalia being really hybrids.

Mr. Hinton replied that he knew of no natural hybrids amongst wild mammals, but that Professor Lönnberg claimed to have come across instances. Birds were the highest group of vertebrates in which there was reasonable evidence of hybrids occasionally occurring.

Dr. R. Lloyd Praeger (Visitor) gave an account of his experience of the occurrence of natural hybrids in the *Sempervivum* group of plants, especially in the Canary Islands. Out of some fifty species, at least thirty-five are known to cross, and the group is the most hybrid-producing one in the Canary Islands. Examples were given of the characters of some of the hybrids. Barrenness of the hybrids in the group is undoubtedly general.

Dr. Stapf expressed his belief in the existence of a large number of hybrids which were more abundant in some families than in others. Although there was no proof of a new species having arisen through natural hybridization, the disappearance of the parents of a hybrid progeny might lead to the latter being taken for a polymorphic species. Isolation of a hybrid progeny might also lead to the appearance of a new species. He emphasized the desirability of experimental research into the question of hybridization being undertaken.

Prof. R. R. Gates recalled that the late Dr. W. Bateson had instanced several cases of hybrids in birds. He advocated the extension of genetic methods in the investigation of the phenomena of hybridization, and pointed out that pure species possessed a certain stability which was lacking in their hybrid progeny.

Mr. R. Paulson related his experience in coming across what appeared to be instances of hybridization occurring in *Silene* in the Vallée de Chavière, the mixed progeny of which have been described as different species by botanists.

Dr. C. L. Huskins drew attention to the fact that Lotsy's theory of evolution by hybridization includes the possibility of "hybridization" within a single nucleus. In 1920 Lotsy suggested that the mutants of *Œnothera* might have arisen through parts of chromosomes being broken off and attached to other chromosomes. Since that date cytological evidence of such changes has been found in *Datura* and in *Drosophila*. By this means new characters may appear in a manner which simulates gene mutation. This feature, which we may call "internal hybridization," may be as important or even more important than ordinary hybridization in producing variation, because it does not commonly affect viability to the extent that ordinary species hybridization may do.

Dr. E. J. Collins referred to the diversity of results subsequent to hybridization between species. The reputed natural hybrids of *Gaultheria* and *Myrtus* from the New Zealand flora show a

complete range of forms between the two original parents. Since the F_1 is fertile it is suggested that these forms represent many of the recombinations which the bringing together of two chromosome complexes makes possible. The chromosome numbers of the various species of *Gaultheria* and *Myrtus*, however, appear not to have been recorded.

In crossing *Saxifraga rosacea* and *S. granulata*, a *non-segregating* F_2 generation was obtained; it was understood that both parents had a chromosome complex of 16 individual chromosomes, and the *fertile* F_1 originating the uniform progeny was tetraploid (32). The incidence of tetraploidy is significant in fertility, and it will be interesting to have some account of its mode of origin, whether gametic or somatic, when the cytological research has been completed.

Dr. Collins proceeded to give examples from his own experimental work where the F_1 *was completely sterile.* Three species of *Calceolaria*, *C. augustifolia*, *C. integrifolia* (18), and *C. cana* (18), have been crossed with *C. alba* (36), used as the pollen parent. The hybrid plants in each cross resemble the male parent in a marked degree and might easily be mistaken for that species. The male parent in each of the crosses possesses 36 chromosomes, and it may very well be that in the chromosome complex of the F_1, *alba* derivatives have a preponderating effect.

He recalled the origin of the sterile diploid *Primula kewensis* (18) from a cross between *P. floribunda* (18) and *P. verticillata* (18). Miss Pellew records how the diploid hybrid has been observed to set seed on three occasions since its first production in 1900. Each time its seed has given rise to fertile plants with the tetraploid number of chromosomes ($4n = 36$). On the occasion directly observed by Miss Pellew, the axis carrying fertile flowers was indubitably tetraploid, so that the doubling of the chromosome complement occurred in some somatic division. Miss Pellew explains the fertility of the tetraploid and its comparative constancy by adopting Winge's hypothesis of intraspecific pairing of the chromosomes with the provision that occasional pairing between unlike chromosomes (interspecific pairing) occurs which leads to sporadic variation.

To sum up, it may be said that since in the hybridization of species, chromosome complexes, varying probably in character and frequently in the number of individual chromosomes, are brought together, it is not surprising that such diversity of results occurs.

14th March, 1929.

Sir Sidney F. Harmer, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous meeting, held on Thursday the 28th February, 1929, having been circulated, were taken as read, and confirmed

A statement of the names of donors of gifts received since the previous meeting was read and laid on the table.

The following Fellows signed the Obligation in the Book of the Charter and Bye-Laws and were admitted:—Augustus Daniel Imms, Stephen King Montgomery, Stanley Wells Kemp, and George Olds Cooper.

The PRESIDENT read the following letter addressed to him by Admiral Sir Lionel Halsey, G.C.M.G., G.C.V.O., K.C.I.E., Comptroller and Treasurer of His Royal Highness The Prince of Wales's Household:—

St James's Palace, S.W.
5th March, 1929.

DEAR SIR,—

I write in reply to your letter of the 2nd instant, addressed to Sir Godfrey Thomas, to say that The Prince of Wales will be very pleased to accede to the request of the Council of the Linnean Society of London to become an Honorary Member of the Society.

Yours faithfully,
LIONEL HALSEY,
Comptroller.

Sir Sidney F. Harmer, K.B.E., F.R.S.

The intimation that His Royal Highness had graciously consented to honour the Society by becoming an Honorary Member was received with acclamation.

Certificates of recommendation of the following candidates for election to Fellowship were read for the second time:—Frank William Jane, Timeri Murari, Edmund Arthur Robins, Godfrey Michael Graham, Herbert William Roy Bertrand, Edward Shefford Lyttel, Francis Gayner, William Alfred Cunnington, David Leslie Miln, Thomas Edward Miln, Herbert Gordon Garratt, Rakhal Das Bose, Kenneth Thomas St. George Cartwright.

Certificates of recommendation of the following candidates for election to Foreign Membership were read for the second time:—Theodor Mortensen, Bohumil Němec, Carl Hansen Ostenfeld.

Certificates of recommendation of the following Candidates for election to Associateship were read for the second time:—Hilderic Friend, Herbert Womersley.

Dr. E. J. Allen, F.R.S., delivered the HOOKER LECTURE entitled "The Origin of Adaptations." The President conveyed the thanks of the Society to Dr. Allen for his excellent lecture. The following supported the President's remarks and took part in

the discussion that followed the lecture:—Sir Arthur Smith Woodward, Mr. J. T. Cunningham, Mr. C. F. A. Pantin, Dr. F. A. Bather, Dr. W. T. Calman, and Dr. G. P. Bidder. The lecture is printed on pages 119–138.

4th April, 1929.

Sir Sidney F. Harmer, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous meeting, held on Thursday the 14th of March, 1929, having been circulated, were taken as read, and confirmed.

A statement of the names of donors of gifts received since the previous meeting was read and laid on the table.

The following Fellow signed the Obligation in the Book of the Charter and Bye-Laws and was admitted:—Cecil Stevenson Garnett.

The President announced that His Royal Highness The Prince of Wales had signed the Book of the Charter as an Honorary Member of the Society, and the special page containing the signature of His Royal Highness was exhibited to the meeting.

The President also announced that the Council had unanimously resolved to award the Linnean Gold Medal to Prof. Hugo de Vries, F.M.L.S., Lunteren, Holland.

Certificates of recommendation for election of the following candidates to Foreign Membership were read for the third time:—Theodor Mortensen, Bohumil Němec, Carl Hansen Ostenfeld.

The following candidates were balloted for and elected Fellows:—

Frank William Jane, Municipal Museum, Liverpool.
Timeri Murari, B.Sc., Mysore Agricultural Department, Bangalore, India.
Edmund Arthur Robins, Watford, Herts.
Godfrey Michael Graham, M.A., Fisheries Laboratory, Lowestoft.
Herbert William Roy Bertrand, Govinna, Ceylon.
Rev. Professor Edward Sheffford Lyttel, M.A., University College, Southampton.
Francis Gayner, M.A., M.B., Redhill, Surrey.
William Alfred Cunnington, M.A., D.Sc., Ph.D., St. Bartholomew's Medical College.

David Leslie Miln, Chester.
Thomas Edward Miln, Warrington.
Herbert Gordon Garratt, M.A., Dudley Grammar School.
Rakhal Das Bose, B.Sc., Imperial Agricultural Research Institute, Pusa, Bihar.
Kenneth Thomas St. George Cartwright, B.A., Imperial College of Science.

Certificates of recommendation for election to Fellowship of the following candidates were read for the first time:—Stanley Thomas Burfield, Edgar Johnson Allen, Edgar Barton Worthington.

The President announced that a ballot for the election of candidates for Fellowship would be held on the 24th May, 1929.

A ballot was held for the election of a candidate to fill the vacancy in the list of Associates. There were two candidates, the Rev. Hilderic Friend and Herbert Womersley, F.E.S. The greater number of votes was in favour of Herbert Womersley, who was therefore declared as elected.

Mr. G. M. Graham read his paper on "The Natural History of the Victoria Nyanza," which was illustrated with lantern-slides.

The Fishing Survey of Lake Victoria 1927–1928 was carried out, by the author and Mr. E. B. Worthington, to solve a problem in economic fisheries. This involved a study of the general ecology of the lake. The Survey was made from a tug, s.s. 'Kavirondo,' chartered for seven months. The Cichlid fish, *Tilapia esculenta* is the most important food species, and next in importance is *T. variabilis*. The two are distinguished in habit and form; including the development, in *T. variabilis* only, of an interesting secondary sexual character, the genital papilla. The distribution of *T. esculenta* is curiously limited. This was finally explained (by its habit of feeding on the living deposits of diatoms that adhere to weeds or the lake bottom) in terms of the South-east Trade Wind; related phenomena being the distribution of *Papyrus* and that of rainfall—involving scenery and the varying agricultural fertility of the lands bordering on the lake. Probably the distribution of *Protopterus* is related to the same cause. The Darter or Snake-Bird (*Plotus anhinga*) has the same distribution as *T. esculenta* (differing in this from the ubiquitous Cormorants), but this is unexplained.

A truly plankton-feeding fish, (as distinguished from *T. esculenta*, which feeds on "adherent" members of the plankton), is *Engraulicypris argenteus*, a Cyprinoid, which, in this large lake resembling the sea in the presence of a stable plankton population, has a form similar to the Clupeidæ. *Engraulicypris* has freely floating eggs

and fry, and, oddly enough, the eggs resemble those of a pilchard in having a large peri-vitelline space. *Engraulicypris* is probably the most important link between the plankton and the predatory fish, being an important food of certain *Haplochromis* spp., some of which are present in enormous numbers. *Haplochromis* is preyed upon by the Siluroids *Schilbe*, *Bagrus*, and *Clarias*, the last of which adopts the process of feeding directly on zooplankton in open water. Adult *Bagrus* and *Clarias* are too large to be attacked by other fish, but are often heavily parasitized. Molluscan-eating fish are *Protopterus* and *Barbus* and certain *Haplochromis* (etc.) spp. *Mormyrus* feeds almost exclusively on fly-larvæ, and *Synodontis* on fly-larvæ and prawns.

Excluding the shore, the lake may be divided into certain ecological zones:—(1) the Surface Waters; (2) the Deep Mud Region (190-230 feet); (3) the Intermediate Zone (50–150 feet); (4*a*) Shallow Water (less than 50 feet) where the ground is exposed; (4*b*) Shallow Water where there is shelter. These zones are distinguished by their fauna.

The Tropical situation of the lake results in:—(1) a constant plankton population; (2) rapid growth and decay, with perhaps more virulent parasitism; (3) more or less continuous reproductive activity.

The President expressed the thanks of the meeting to Mr. Graham for his very interesting paper. He considered it unfortunate that Mr. Graham had not had more opportunities of settling the question whether or not the crocodiles of the Victoria Nyanza feed on the lake fishes, as the dentition of crocodiles is piscivorous.

Mr. J. O. Borley, Dr. W. A. Cunnington, Mr. J. R. Norman, Mr. W. S. Rowntree, and Dr. E. S. Russell expressed their appreciation of Mr. Graham's paper, and paid tribute to the great value of his investigations. Dr. Cunnington pointed out that this was the first time that any of the African lakes had been systematically investigated, and he hoped that the biology of the other African lakes would be studied on similar lines. Mr. Norman in his remarks mentioned that the collections brought back by Mr. Graham were excellently preserved and that they contained a considerable number of new species.

Dr. G. P. Bidder read his paper entitled "On the Classification of Sponges," of which the following is an abstract:—

In 1927 * reasons were shown for regarding Hexactinellida, on account of their naked cells, as forming a phylum separate from the Horny, Calcareous, and Four-ray Sponges, with no common ancestors below Choanoflagellata †. Recognizing that the spicules of Clavulidæ, Desmacidonidæ, and Renieridæ are really triaxon spicules with one ray or pair of rays markedly predominant ‡, it was

* British Association (D) Sectional Address.
† *Cf.* Minchin, 1905, Zool. Anz.
‡ *Cf.* de Laubenfels 1927, Ann. & Mag. N. H.

proposed to place the groups of which this could be shown, as Orthogonida, in the same phylum as the Hexactinellida, on the ground that the secretion of cubic opal was probably evolved only once.

Further consideration has indicated that the descent of Needle-sponges from Hexactinellida is on these lines not proved and doubtfully probable. If the cubic opal, which forms alike the birotulæ of the river-sponge *Ephydatia* and the amphidiscs of the glass-rope *Hyalonema*, appears in these two sponges in consequence of their common descent, then the important functions of the intercellular jelly in *Ephydatia* have been evolved independently from those of the intercellular jelly in calcareous and horny sponges. Again, no spongin has been demonstrated in Hexactinellida, but spongin unites the spicules in freshwater and other spindle-sponges. The chelæ of Desmacidonidæ are clearly of cubic opal (*Melonanchora* and *Merlia* have chelæ regularly symmetrical about three planes at right angles to each other), but spongin is plentiful, sometimes to the degree of forming the whole functional skeleton.

Investigating *Desmacidon ægagropila* on this point, it was seen that the spongin cementing together the spicules of the bundles is secreted by flask-shaped cells with slender necks, individually similar to the spongoblasts figured by Schulze * as secreting the fibre in the bath-sponge, or by Bidder as secreting fibre and cuticle in *Hircinia* † (though in *Desmacidon* the definite epithelium of spongoblasts over the fibre, which is so characteristic in the horny sponges, has not yet been made out).

Therefore three important organs, absent in Hexactinellida, are possessed by Renieridæ and Desmacidonidæ in common with the Sponginæ :—(*a*) a supporting intercellular jelly; (*b*) spongin secreted by long-necked gland-cells; (*c*) a hydraulic system producing a powerful current from the vent.

The probable conclusion is, then—rather than that this triple endowment has been evolved twice—that the secretion of cubic opal has been evolved twice.

In lieu of the suggestion in 1927, the following arrangement is now proposed :—

Classification.

Sub-Kingdom PARAZOA Sollas (= *Porifera* Grant).—Sponges.
(Colonial Choanoflagellata consisting of cells of more than one kind.)

Phylum i. Nuda Bidder, *s. s.*—Naked Sponges.
(Sponges which have originated from branching colonies of naked cells.)

* Z. f. W. Z., 1879.
† P. R. S., 1892 *a*. (*Cacospongia* by faulty determination.)

Class 1 and Order (1) **Hexactinellida** Auctt.—Glass Sponges.

Phylum ii. GELATINOSA nov.—True Sponges.

Class 2 and Order (2) **Monaxonellida** Auctt.—Needle Sponges.

Families: Clavulidæ (Pincushions); Desmacidonidæ (Claw-sponges); Axinellidæ (Fans); Renieridæ (Spindle-sponges); and, probably, Monocrepidæ (Stony Needle-sponges).

Class 3. **Ceratosa** Bowerbank.—Horny Sponges.

Order (3) *Dendroceratida* Minchin.—Horny Bushes.
(4) *Dictyoceratida* Minchin.—Horny Nets.

Class 4. **Calcarea** Bowerbank.—Chalky Sponges.

Order (5) *Calcaronea* Bidder.—Banana-chalks.
(6) *Calcinea* Bidder.—Lace-chalks.

Class 5. **Tetraxonida** Ldf.—Four-ray Sponges.

Order (7) *Plakinida* F. E. Schulze.—Flat Sponges.
(8) *Tetractinellida* Auctt. *s. m.*—Grapnel-sponges.
(9) *Donatiida* Auctt. *s. m.*—Plane-fruits.
(10) *Lithistida* O. Schmidt.—Stony Sponges (but probably only the Tetracladidæ belong here).

Old names have been retained wherever possible. The principal difference from Topsent's classification * is that he divides Sponges into the three classes:—*Calcaria*, *Triaxonia*, and *Demospongiaria*; the last including three sub-classes, *Tetractinellidæ*, *Monaxonellida*, and *Ceratellida*. He also still unites *Donatia* (*Tethya*) with the Clavulidæ in his group *Hadromerina*, his first order of Monaxonellida. As elsewhere stated †, the spicules of *Donatia* are of tetrahedral opal (it is due to a perspective error that a proportion of tylasters have so often been figured as rectangular 6-rayed crosses: careful focusing always shows a fore-shortened pair of rays masked in one of the others). Dendy ‡ included all the Monaxonellida in his Tetraxonida, equating impossibly the centrifugal rectangular cross-hilted spicules of Clavulidæ with the centripetal tetrahedral grapnels of Tetractinellida. Hentschel agrees with him so far as to include Clavulidæ with Donatiidæ in Tetraxonida, but restores Vosmaer's Cornacuspongida for the other Monaxonellida with Dictyoceratida, separating Dendroceratida as a fifth order.

The classifications in the text-books of Minchin, W. J. & I. B. J. Sollas, and Vosmaer, are too well known for citation to be requisite, and with present knowledge earlier schemes have now antiquarian interest.

* Topsent, 1928, "Campagnes . . ." Monaco.
† 'Nature,' 1925, cxv. p. 299.
‡ *E.g.* 1924, 'Terra Nova,' Porifera.

Mr. Maurice Burton (Visitor) expressed his agreement with Dr. Bidder in the wide severance of Hexactinellida from all the other sponges; it was a bold step to create two new phyla, but he was not prepared to say that impartial reflection would show that it was exaggerated. He disagreed with the position given to Ceratosa in the classification: they graduate imperceptibly into the Monaxonellida; *Hyatella sinuosa*, for example, may be found as a purely horny sponge, or careful examination may show a few echinating spicules marking it as a Desmacidonid. He asked where the Myxospongiæ are in this classification. The "Lithistida" contains members of every group of the Monaxonellida, and should be distributed.

The President said that all who had even a superficial acquaintance with sponges must have felt the difficulty of supposing that their cells have the memory and powers necessary for the shaping of the elaborate patterns of the different spicules, and if these can be shown to be the result of simple physical laws, the philosophic problem is much simplified. He was startled by the suggestion to divide sponges into two phyla, but after what Dr. Bidder and Mr. Burton had said, he felt that the suggestion demanded respectful consideration.

Dr. Bidder agreed that the Ceratosa offer a difficult and doubtful problem, but more research was required to determine whether a needle-sponge which has lost its spicules histologically resembles the true horny sponges. With regard to the so-called Myxospongiæ, he placed, as in previous papers, *Oscarella* with the Plakinida and *Halisarca* with Dendroceratida.

18th April, 1929.

Sir Sidney F. Harmer, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous meeting, held on Thursday the 4th April, 1929, having been circulated, were taken as read, and confirmed.

A statement of the names of donors of gifts received since the previous meeting was read and laid on the table.

The following Fellow signed the Obligation in the Book of the Charter and Bye-Laws and was admitted:—William Alfred Cunnington.

Certificates of recommendation for election of the following candidates to Foreign Membership were read for the fourth time:—Theodor Mortensen, Bohumil Němec, Carl Hansen Ostenfeld.

Certificates of recommendation of the following candidates for Fellowship were read:—For the second time in favour of Stanley Thomas Burfield, Edgar Johnson Allen, and Edgar Barton Worthington. For the first time in favour of Bashambar Nath Chopra.

In accordance with Chap. X, Sect. VII of the Bye-Laws, the following Fellows were nominated by the President to be Auditors of the Treasurer's Accounts for 1928–29, and were elected by a show of hands:—

Representing the Council { Mr. I. H. Burkill. / Mr. Francis Druce.
Representing the Fellows { Mr. E. T. Browne. / Mr. D. J. Scourfield.

The PRESIDENT gave the following further account of "Pelorus Jack":—

The Minutes of the General Meeting, 13th December, 1928, contain a reference to the dolphin which was known as "Pelorus Jack" and is believed to have been a specimen of Risso's Dolphin, *Grampus griseus*. The main facts connected with the history of this remarkable individual are contained in a pamphlet, by Mr. James Cowan, entitled 'Pelorus Jack, the White Dolphin of French Pass, New Zealand,' and published in 1911 (Auckland, N.Z., Whitcombe and Tombs, Ltd.). The animal is there said to have been first seen by Capt. W. K. Turner "forty years ago." After remaining for about twenty years off Lewis Island, it moved to the mouth of Pelorus Sound, at the northern extremity of the South Island (New Zealand), just to the east of D'Urville Island and French Pass, and therefore on the route of steamers from Nelson to Wellington. It is not certain, however, whether the animal seen by Capt. Turner was the individual which later formed the strange habit of escorting steamers.

As a result of enquiries which were recently made by Dr. W. Rushton Parker, F.L.S., letters have been received pointing to the conclusion that "Pelorus Jack" died about April 1912. The following extracts from this correspondence will be of interest to the Society:—

"'Pelorus Jack' was shot at many times, but he was an object of such interest that on 26th September, 1904, he was protected for five years by an Order-in-Council of the New Zealand Government; on 23rd May, 1906, he was again protected, in Clause 36 of the Fisheries Regulations, for another five years." [Mr. Cowan records a further prolongation, April 24, 1911.]

"During the time he was known, he met practically every steamer, by day or by night, on the Nelson–Wellington run, and escorted each one, leaping and gambolling under the bows for some twenty minutes. Some supposed he was simply rubbing off barnacles.

"The distance he escorted the steamers was something over five miles, and lay off Clay Point, from midway across Admiralty Bay off D'Urville Island to midway across Pelorus Sound off Chetwode Island.

"He would sometimes disappear for a few weeks or even months, and then reappear in his old haunts. In April, 1912, however, he disappeared finally, and no trace of him has since been seen." [From Mr. Johannes C. Andersen, Librarian of the Alexander Turnbull Library, Wellington, 19th November, 1925.]

"My personal acquaintance with 'Pelorus Jack' dates back to 1882, and I saw him several times up to 1908 when on steamer trips through French Pass (between D'Urville Island and the mainland of the South Island).

"The story in Nelson was that some Norwegian whalers . . . had harpooned 'Jack'; . . . but this story was disproved by an entry in the log of one of the Navy Gunboats stating that 'Pelorus Jack' had accompanied the ship through the French Pass, and this entry is dated four days *after* the Norwegian ship had left the district!

"The Union Steam Ship Co. story is that 'Jack' accompanied the s.s. 'Mapourika'—a one-propeller steamer—through the Pass as long as she was on the Nelson–West-Coast service but that he disappeared when that vessel was replaced by the s.s. 'Arahura'—a *twin*-screw steamer,—and the theory is that 'Jack' accidentally got between the propellers and was smashed to little bits. I have been told various years for the date of his final disappearance—from 1910 to 1914. The only thing certain is that he has disappeared and never a trace of his body has been found." [From Mr. Fred Barkas, Timaru, New Zealand, 18th February, 1929.]

The President suggested that, in the light of this story, we may possibly have to review our incredulity in regard to the classical narratives of friendliness of dolphins towards mankind.

Dr. G. P. Bidder mentioned Arion, and Pliny's story of the Syracusan boy who was friends with a dolphin, and narrated a curious experience of his own in a 3-ton cutter. The boat was reaching away from Stoke Point (Plymouth) in a strong easterly wind, going about 7 knots and carrying a lot of helm. Five or six porpoises suddenly joined her and played alongside her or in the bubbles from her rudder. One on the starboard quarter was gently rising and falling in the water, so close that from the steersman's seat one could have touched him with the hand. This continued for several minutes, then the wind dropped, and when the speed of the boat sank to 2 or 3 knots the porpoises all went off, as if disgusted. None of them touched the boat so that it could be felt.

It is difficult to believe in the scraping off of barnacles; dolphins leaping across and across the sharp cutwater of a liner doing 16 knots are clearly delighting in athletic skill. We are not dealing with the tiny, smooth brain of a fish, but with a large

and extremely convoluted brain, probably necessary for the bold submarine navigation of the Cetacea. It is not impossible neither improbable that they are susceptible to music; an acute ear may be of great value in enabling them to tell, from the sound of the surf, the proximity and the nature of the shore; and the sounds from a ship may constitute her attraction.

Mr. H. N. Ridley related that on various occasions off the Dindings, on the coast of the Malayan Peninsula, his launch had been escorted by dolphins, which used to rub themselves against the launch and gambol so closely to it that he was able to slap them. The dolphins did not rub themselves against the launch to clear themselves of barnacles, for they had none.

Lt.-Col. Tull Walsh suggested that the origin of Pliny's story went back to the son of Poseidon, who was figured seated on a dolphin on some ancient Greek coins.

The President expressed his disbelief in the explanation of dolphins rubbing themselves against ships in order to clear themselves of barnacles, for the latter seldom, if ever, were found attached to dolphins. He referred to the alleged former co-operation of "porpoises," probably a species of *Tursiops*, with Queensland natives, in Moreton Bay. A shoal of fishes having been located, the porpoises were accustomed to drive them inshore, in response to a definite signal given by their human friends, who were thus able to capture their prey from the beach with nets and spears. This assistance was acknowledged by the offer of fishes on the end of a spear, and a porpoise which had not been thus rewarded would swim backwards and forwards along the beach until its wants had been satisfied. The story is a remarkable one, but it is supported by what appears to be reliable evidence, for which see Mr. Longman's summary in the 'Memoirs of the Queensland Museum,' vol. viii, 1926, p. 275.

Dr. G. Claridge Druce, F.R.S., gave an account, illustrated with lantern-slides, of his experiences during a botanical tour which he had recently made in Cyprus. The following is an abstract of his account:—

The botanical history of Cyprus is a long one. Theophrastus mentions some of its products, Dioscorides alludes to its Origanum oil, and Drummond in 1754 was the first to record a definite endemic species, *Quercus alnifolia*; a second, *Onosma fruticosum* was found by Labillardière in Feb. 1787; *Putoria* and the *Cedrus* had also thus early been noted. Its true scientific exploration was begun by Sibthorp in 1787 accompanied by his artist, Bauer, the discoverer of *Pinguicula crystallina*. Three of his original paintings of the island were shown—Monte Croce 80 (Stavrovuni), the Monastery 81, and Ipsora 82; they were five weeks on the island, and noted 313 species, many of them being new to science. A few scattered notes were made between this date and 1831, when Aucher Eloy added many plants.

The new species were published chiefly by Boissier. T. Kotschy visited the island three times between 1840 and 1862 and brought up the number of species to 1050, of which about 90 are cultivated, but there are at least 800 definite species in his list. Gaudrey, Hooker, Hanbury, Haussknecht, J. Ball, Sir Samuel Butler, Sintenis and Rigo, W. Barbey, T. Pichler, E. Deschamps, G. E. Post, E. Hartman, and others have added to the knowledge of the Flora. Mr. A. Lascelles (now Sir Alfred), when he was Judge there, and his sister, Miss Lascelles, made considerable collections in 1900–2; these with Miss Samson's plants are at Kew. The list contains about 46 additional species.

The author climbed Chionistra, Hag Hilarion, Pentadactylos (for some distance), and searched the high ground at Platres, Pissuri, Prodromo, Kikkou, Agros, etc.; also the salt-marshes at Larnaca and Limassol, but the season was not forward enough for either the mountains or the marshes; also the area around Paphos, Morphou, Myrtru, Lapithos, Kyrenia, Salamis, Nikosia, Kythræa, Famagusta, etc. He succeeded in verifying Sibthorp's records (hitherto not refound) of *Cheilanthes fragrans* in two localities—*Camelina*, *Linaria Cymbalaria*, which is really *L. longipes*.

He verified Kotschy's unlocalized record of *Silene Behen* and Miss Samson's of *Carduus pycnocephalus*. One of the most interesting additions was that of *Lamprothamnium papulosum* J. Groves, a great extension in the north-east.

Dr. Druce paid a warm tribute to the very complete, accurate, and interesting account of the Vegetation of Cyprus, which was published in 1914, by Prof. Holmboe, of Oslo, as the results of his nine months' exploration. He enumerates 1276 species, 73 subspecies, and about 60 varieties. It may be added that Sibthorp, on his visit to the island in 1787, found 313 species. Dr. Druce's 21 days' visit in March and April 1928 resulted in finding 746 species, of which 40 species, including 6 adventives and 8 varieties, were new to the island, including probably a new Tulip and *Mentha*, and a new variety of the Ivy. The lecturer showed nearly seventy lantern-slides from his original photographs, and these illustrated the scenery of the island and the places where the plants were obtained, including the neighbourhood of Limassol and its Salt-lake, the Tower of Kolossi, once the headquarters of the Knights Templars, and views of Carob-Trees, Olives, Cypress, and *Pinus halepensis*, of the coast of Paphos with its deposits of *Posidonia*, and the Temple of Venus. Views of the coast between Limassol and Larnaca, a place which Sibthorp made his home during his exploration, of Nicosia the capital, and of Kythræa and its weird mountain Pentadactylos, the home of many rare plants: of Hag Hilarion, which Richard Plantagenet captured, where *Brassica Hiliarionis*, *Cyclamen persicum*, *Scilla sibirica*, etc. grow, whence fine views of the pleasant seaside resort of Kyrenia are to be had, as well as a glorious prospect over the mountain range. Then

numerous views of the Troodos were shown, including the highest summit Chionistra, whence *Crocus Cyprius* was obtained in the spot where Sibthorp discovered it, as well as *Ranunculus cadmicus*.

Views of the asbestos-mountain, of Platres and Prodomo, were shown; near the latter place *Pinguicula crystallina* in its classical habitat was found. Kikko Monastery, in which he stayed, and the great Cedar forest, trees of *Pinus brutia*, *Juniper fœtidissima*, *Cedrus brevifolia*, *Quercus lusitanica* were also given, as well as of the Gambo valley, the coast of Morphou, the Messarian plain, of the walled city of Famagusta, and the ruins of Salamis. A large number of plants were shown, and the lecturer expressed his indebtedness to Mr. A. R. Horwood and other members of the staff at Kew for identifying so many of the specimens.

Dr. G. S. Carter read the paper by himself and Mr. L. C. Beadle, which was illustrated with lantern-slides, on "Respiratory Adaptations among Fishes of the Swamps of the Paraguayan Chaco."

It has been shown in a previous paper that the fauna of these tropical swamps is normally exposed to water greatly lacking in oxygen. In this paper the adaptations by which the fishes of this fauna are able to live in such conditions are discussed.

There are two sources from which these fishes may obtain a further supply of oxygen—the well-oxygenated surface-film of the water, and the air above the water. Of the twenty species collected in the swamps, eight breathe air and the remainder make use of the surface-film, many of them living in very foul pools by this means.

The respiratory adaptations of two of the air-breathing species (*Lepidosiren paradoxa* and *Symbranchus marmoratus*) have been adequately described, and are not further discussed. The remaining species show four types of aerial respiration, represented by the genera: (1) *Erythrinus*, (2) *Hypopomus*, (3) *Callichthys* and *Hoplosternum*, and (4) *Ancistrus*. These four types are described:—

(1) The central part of the air-bladder in *Erythrinus* has long been thought to be respiratory; the structure of its wall is described. In the thickness of the wall are a large number of cells opening to the central cavity and separated from each other by very thin walls containing a dense capillary network. Experiment showed that air is normally passed in and out of the bladder, and that this air is necessary for the life of the fish in deoxygenated water. Analyses gave evidence of absorption of oxygen and of a less excretion of carbon dioxide in the bladder.

(2) In *Hypopomus* aerial respiration is carried on in the gill filaments. The only structural adaptations to this end are the very large size of the gill-chamber and the unusually great length of the secondary folds of the filaments. These are longer than in

any other fish except *Symbranchus*, in which aerial respiration of the same type occurs.

(3) *Callichthys* and *Hoplosternum*.—The intestine in these fish has been considered to be respiratory by previous authors. The structure of its wall is described, and is shown to be very similar to that of the intestine of the loach (*Misgurnus*), which is also respiratory. It was shown by experiment that air is passed in and out of the intestine, and that the respiration carried on in this organ is necessary for the life of the fish under all conditions. Analyses again showed absorption of oxygen and a less excretion of carbon dioxide.

(4) *Ancistrus*.—The stomach is thin-walled and filled with air during life. Its epithelium greatly resembles that of the intestine of *Callichthys*. Air is exchanged between the stomach and the exterior, and analyses showed absorption of oxygen. This type of respiration occurs so soon as the larva is hatched.

The development of the respiratory epithelium in the last two types is described.

In a general discussion of aerial respiration in the fishes, it is pointed out that, so far as is known, the accessory organs are used chiefly for absorption of oxygen, and only to a less extent for excretion of carbon dioxide. It is suggested that this is due to the evolution of these organs for life in a medium poor in oxygen, and not for migration out of the water. The gills are still present in almost all these fishes, and natural waters are not saturated with carbon dioxide; also aquatic respiration is probably far more efficient than aerial. Most of the excretion of carbon dioxide is therefore carried on in the gills, but the absorption of oxygen must take place almost entirely in the accessory organ, owing to the absence of the gas in the water.

The circulation of the blood through these organs is discussed.

The majority of these fishes live in shallow and stagnant tropical fresh waters. This is taken to be a confirmation of the suggestion made in the previous paper that such waters are in general largely deoxygenated.

Aerial respiration is a necessary preliminary to migration on to the land. It is suggested that in the evolution of the vertebrates aerial respiration was evolved in waters of this type as an adaptation to lack of oxygen while the fish was purely aquatic, and that this development opened the way to the later changes definitely associated with the migration.

Mr. W. S. Rowntree said he had listened with great interest to the paper, and would be very glad if Dr. Carter could give more information about the curious opening of the ductus pneumaticus on the left side in *Erythrinus*.

Dr. Carter regretted, in the pressure of the necessary observations on environment, that they had been unable to add anything on this point.

The President said that he was sure he was expressing the feelings of everyone present in saying that Dr. Carter had given them an extremely interesting and valuable paper. It was at once a carefully worked out study in evolution, in morphology, and physiology, and he congratulated its authors, Dr. Carter and Mr. Beadle, on the success of their labours.

2nd May, 1929.

Dr. W. T. Calman, F.R.S., Vice-President, in the Chair.

The Proceedings of the previous meeting, held on Thursday the 18th April, 1929, having been circulated, were taken as read, and confirmed.

A statement of the names of donors of gifts received since the previous meeting was read and laid on the table.

The following Fellows signed the Obligation in the Book of the Charter and Bye-Laws and were admitted:—Thomas Edward Miln and Miss Nora Cameron Rogers.

Certificates of recommendation of the following candidates for Fellowship were read:—For the second time in favour of Bashambar Nath Chopra. For the first time in favour of Ernest Philip Foquett Sutton.

The following candidates were balloted for and elected as Foreign Members:—

Dr. Theodor Mortensen. Superintendent, Zoological Museum, the University of Copenhagen.

Prof. Carl Hansen Ostenfeld. Professor of Botany, The University of Copenhagen.

Prof. Bohumil Němec. Professor of Plant Anatomy and Physiology, Charles University, Prague.

The Vice-President, in the Chair, announced that the Anniversary Dinner would be held at the Criterion Restaurant, Piccadilly Circus, on Friday the 24th May, 1929, at 7.15 p.m.

Mr. H. W. Monckton, Vice-President, read, in accordance with the injunctions in the Charter, the following proposed

alterations in the Bye-Laws, which had been approved by the Council:—

[*Note.*—The alterations as ultimately passed on December 5th, 1929, having been read on November 7th and 21st, differ slightly from the text here proposed:]

CHAPTER I.

Of the Election and Admission of Fellows.

SECT. VI. The following to be substituted for the last sentence of the second paragraph in Section VI.

"The Council shall decide as to the number of Ballots to take place at a Meeting, having regard to the number of vacancies at the time, and the Council shall select from the certificates the candidates whose names shall be offered for election at that Meeting."

SECT. X. Bye-Law, Chapter I, Section X, to be repealed to the words "Annual Contributions," and the following to be substituted for the part repealed:—

"No person elected a Fellow of the Society shall be entitled to exercise any privilege as such, nor shall he be admitted nor his name entered in the List of the Society until he shall have paid his Admission Fee if any and the contribution for the current year and signed the usual obligation for the payment of Annual Contributions, and unless he pay his Admission Fee if any and the contribution for the current year and sign the Obligation within two calendar months or within such further time as the Council may grant, the election of such Fellow shall be void."

CHAPTER IV.

Of the Foreign Members.

SECTIONS I to IV inclusive to be repealed and the following to be substituted for them:—

"I. The number of Foreign Members shall not exceed Fifty. Any Fellow of the Society may propose a person for election as Foreign Member by a Certificate signed by himself and other Fellows. Such Certificate shall state the name and nationality of the person proposed and give some note of his published work and shall be given to the Assistant Secretary.

"II. The election of Foreign Members shall be by Ballot and the date of such Ballot shall be fixed by the Council.

"III. The Certificates proposing Foreign Members shall be filed by the Assistant Secretary, and in the event of a vacancy or vacancies in the List of Foreign Members the Council shall select from the persons so proposed the number necessary to fill the vacancy or vacancies, and the names of the candidates so selected shall be read at three General

Meetings and the Ballot shall take place at the meeting at which the Certificate is read the third time.

"IV. No person shall be declared to be elected a Foreign Member who has not received the votes of two-thirds of the Fellows balloting."

CHAPTER V.

Of the Associates.

Sections I to III inclusive to be repealed and the following to be substituted for them:—

"I. The number of Associates shall not exceed twenty-five. They shall include only such Persons as usually reside in the British Dominions, and who for any reason are not in a position to offer themselves as Candidates for election as Fellows, but whose work as Naturalists deserves honourable recognition, and who are likely by attendance at its Meetings, or by the communication of scientific notices, to benefit the Society.

"II. Any Fellow of the Society may propose a person for election as Associate by a Certificate signed by himself and other Fellows. Such Certificate shall state the name of the person proposed and give some note of his scientific work, and shall be given to the Assistant Secretary.

"III. The election of Associates shall be by Ballot, and the date of such Ballot shall be fixed by the Council.

"IV. The Certificates proposing Associates shall be filed by the Assistant Secretary, and, in the event of a vacancy or vacancies in the List of Associates, the Council shall select from the persons so proposed the number necessary to fill the vacancy or vacancies, and the names of the candidates so selected shall be read at three General Meetings, and the Ballot shall take place at the meeting at which the Certificate is read the third time.

"V. No person shall be declared to be elected an Associate who has not received the votes of two-thirds of the Fellows balloting."

The Sections of Chapter V, at present numbered IV, V, VI and VII, to be numbered respectively VI, VII, VIII, and IX.

CHAPTER XIII.

Of the General or Ordinary Meetings of the Society.

The following to be added to Sect. III:—

"Visitors may be officially invited to attend the General Meetings by the President or Officers. Strangers may attend the Anniversary Meeting only on the invitation of the President."

Mr. H. H. Haines read his paper, which was illustrated with lantern-slides, on "Some Aspects of the New Forest, with special reference to the Changes wrought by Direct or Indirect Human Agency." The following is an abstract of his remarks:—

Brief reference was made to the changes in ordinary grass-land, heath, and commons if grazing, browsing, and fires are excluded. Exclusion in most cases leads to tree-growth, though the second-growth forest resulting may at first differ from what may be taken as the original forest. In a climate like that of Hampshire the land was probably covered with forest except where, possibly, wild animals, especially rodents on chalky or sandy soil, may have been sufficient to keep it in the condition of downland, and where hard pans occur close to the surface. In the New Forest the poverty of the reproduction of trees and the poor aspect of the young growth, where it exists in the open forest, is due chiefly to the grazing, browsing, and trampling of domestic animals, as also is the entire composition of parts of the vegetation. The first evident results of excessive browsing, as is even better seen in some other parts of the world, is the gradual reduction of the underwood to thorny, prickly, or otherwise distasteful species. In forest consisting purely of shade-bearing species, reproduction and undergrowth may be altogether absent. As the trees die off, other forms of vegetation (differing according to soil, according to the intensity of the grazing, and according to whether the land is burnt or not) take possession in place of the original forest; and this is what has happened over a large area of the New Forest. Where fires are excluded, however, and the trees are species relatively distasteful, as with Pine, Yew, and perhaps Holly, woods of these species on suitable land might survive for very long periods. All these trees are eaten to some extent.

The herbaceous flora and fauna are also seriously affected by large numbers of grazing animals, though, in the New Forest, also very largely from collectors and from the direct action of man in clearing and draining. The impoverishment of the fauna and flora of the open heaths is partly accounted for by too much and too severe burning. In the latter case the soil itself gets burned away and the salts washed out by subsequent rains. The author believes, however, that without some burning and browsing the heathlands in Hampshire would mostly give place to Furze and ultimately to woodland.

Even though it may be now impossible to reverse previous legislation by which the Crown and the public ceded to the commoners much more than (in the author's opinion) they could rightfully claim, a corporate expression of opinion may prevent further hurtful legislation, and by representations in the right quarter prevent large increases in grazing and browsing animals, extension of the pannage system, drainage at Government expense, and the straightening of streams, removal of gates of enclosures, and other works incompatible with the existence of the natural forest.

The Vice-President, in the Chair, expressed the thanks of the meeting for the clear and interesting exposition of present conditions in the New Forest which Mr. Haines had given. Owing to lack of time there was no discussion of the paper.

Mr. F. S. Russell (Visitor) gave a general account, illustrated with lantern-slides, of the Great Barrier Reef Expedition and its aims. The following is an abstract of the account:—

The expedition is based on Low Island, forty miles north of Cairns, N. Queensland, and situated eight miles from the mainland and midway between the coast and the great barrier itself. The slides shown illustrated the main features of the island and the lines of research being followed up.

The work is split into two main sections, taken charge of respectively by the shore party and the boat party. The work of the shore party is concerned with an ecological survey of the island and adjacent barrier reef, studies in the growth of coral, and life-histories of economic products, such as pearl oyster, trochus, and bêche-de-mer. Experimental work on the feeding-habits of corals are being carried out in the laboratory.

The sea work entails a complete seasonal survey of the chemical constituents of the sea water and of the plant and animal plankton, together with physical observations such as temperature and transparency.

The expedition arrived on the island in July 1928, and will leave in July 1929, having completed a full year's observations—biological, physical, and chemical—on the life in a tropical coral-reef area.

Mr. G. Tandy gave a preliminary account, illustrated with lantern-slides, of the Vegetation of the Great Barrier Reef. The following is an abstract of his remarks:—

Low Isles present a very interesting set of problems for the botanist. As one comes from the southward they are the first of the "low and wooded" islands of the early navigators to be encountered. The arrangement of a mangrove swamp to windward (with *Rhizophora mucronata* the dominant) and a more or less vegetated cay of coral sand to leeward is found in considerable numbers northwards from here. To understand the formation, the behaviour of the S.E. Trade Wind (pretty constant here from April to November) must be considered.

In early morning it will be at S.S.E. and light, but as the day goes on it will shift to E.S.E. or even E. and freshen. This means that the heaviest seas will commonly be on the north side of the mangrove island. Here the drift of the coral shingle is driving the mangrove back. On the lee side of the swamp, however, they are extending in a westerly direction.

The Vice-President, in the Chair, congratulated Messrs. Russell and Tandy on the results of their labours and on the very interesting story of the expedition.

Dr. A. B. Rendle, expressed his congratulations on the successful results of the expedition, and as a botanist referred more particularly to the botanical results. He mentioned that, although the botanical department of the British Museum had to suffer the loss of Mr. Tandy's services while he was absent with the expedition, the rich material he had brought back would be of great value in elucidating the symbiotic relations of life on a coral reef.

Dr. G. P. Bidder endorsed Dr. Rendle's congratulations on the successful work of the explorers. The return of Mr. Russell, with the very interesting account which had just been given, was a very great relief to the Committee who were responsible for the selection and sending out of the expedition, for no one could hear his narrative and doubt that the expedition was a success. Neither could anyone present to-night doubt that the success was due to very able organisation and control on the part of the leaders of the expedition, and, in recognizing that, he would ask them to remember that the second in command had been Mr. F. S. Russell.

Prof. C. E. Moss remarked upon the similarity of the mangrove swamps shown in the lantern-slides to those which he had seen in estuaries on the coast of Portuguese East Africa, the same genera occurring in both places.

Mr. C. G. Rogers stated that he had observed mangrove swamps along the coasts of the Andaman Islands. There *Rhizophora mucronata* grew furthest out towards the sea, and the elongated rhizomorphs of that species allowed the leaves to be above water for at least part of the time when the tide was low. *Bruguiera*, on the other hand, grew further back and had no rhizomorphs.

Mr. H. W. Pugsley's paper, "A Revision of the British *Euphrasiæ*," of which an abstract is given below, was read in title only.

The British species of *Euphrasia* were first studied by the late F. Townsend, who published a monograph in 1897 (Journ. Bot. xxxv, 321 *sqq.*), adapted from the larger work of Prof. E. von Wettstein of the preceding year. Townsend entirely followed Wettstein's arrangement of the genus and admitted fourteen species as British. Additions to this list have since been made, and the number of species in the 11th edition of the London Catalogue (1925) stands at nineteen.

The relationship of the generic subdivisions, as given by Wettstein, is open to criticism, and seems to have been well modified in Jørgensen's recent work on the Norwegian Euphrasias. Townsend's identifications of the British forms with Continental species,

which appear never to have been independently verified, are clearly inaccurate in some cases.

A revised arrangement of the British forms, and of the groups under which they fall, is proposed.

ANNIVERSARY MEETING.

24th May, 1929.

Sir Sidney F. Harmer, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous meeting, held on Thursday the 2nd May, 1929, having been circulated, were taken as read, and confirmed.

A statement of the names of donors of gifts received since the previous meeting was read and laid on the table.

The following Fellows signed the Obligation in the Book of the Charter and Bye-Laws and were admitted:—Edward Shefford Lyttel, Edmund Arthur Robins, David Leslie Miln, and William Alfred Pritchard Jones.

Certificates of recommendation of the following Candidates for Fellowship were read:—For the second time in favour of Ernest Philip Foquett Sutton. For the first time in favour of Robert Brian Dawson, George Redington, James Herbert Orton, and Joseph Thomas Cunningham.

The following Candidates were balloted for and elected Fellows:—Stanley Thomas Burfield, Edgar Johnson Allen, Edgar Barton Worthington, Bashambar Nath Chopra.

The Treasurer presented his Accounts of the Society, duly audited, for the financial year from the 1st May, 1928, to the 30th April, 1929. On a motion by Mr. W. S. Rowntree, seconded by Mr. Stanley Edwards, the statement of Accounts was adopted.

The Bye-Laws regulating the Election of Council and Officers having been read by the Assistant Secretary, the President declared the Ballot for Council and Officers to be open, and voting began. The Ballot for Council was closed at 5.30 p.m. and for Officers at 6.0 p.m.

Meanwhile the Librarian and Assistant-Secretary presented his Report as follows :—

MEETINGS.—During the Sessions of 1928–29 there were held thirteen General or scientific Meetings, excluding the Anniversary Meeting. From the 25th May, 1928, to the 24th May, 1929, the Council met ten times and the Library Committee seven times.

PAPERS.—At the thirteen General Meetings forty papers were presented exclusive of the Hooker Lecture by Dr. E. J. Allen. Twenty-three of the papers were purely or predominantly zoological and seventeen purely or predominantly botanical. There were five scientific exhibits, all botanical.

ATTENDANCES.—The signature sheets record 768 attendances of Fellows and Associates and 202 of Visitors, or a total of 970. The actual number of attendances was certainly more, as not everyone signs the attendance sheets. According to the sheets, much the smallest attendance of 39 was on the 14th February, 1929, which was no doubt due to the intensely cold weather at that time. The largest attendance, 110, was on the 13th December, 1928. The average attendance was 59 Fellows and Associates and 15 Visitors.

LIST OF THE SOCIETY.—From the 25th May, 1928, to the 24th May, 1929, 31 names have disappeared from the List of the Society, being thirteen Fellows, three Foreign Members, and one Associate by death, eleven Fellows by withdrawal, and three Fellows by removal. The detailed statement is as follows :—

Deceased.

Fellows.—Richard Hind Cambage, Helen Mary England, Frank James Evans, Hugh Findon, Edmund Thomas Gardner, James Lamont, Bella Dytes MacIntosh MacCallum, Oswald Alan Reade, Marcus Samuel Cam Rickards, Henderina Victoria Scott, Thomas Scott, William Turner Thiselton-Dyer, Arthur William Waters.

Foreign Members.—Victor Ferdinand Brotherus, John Merle Coulter, Jakob Wilhelm Ebbe Gustaf Leche.

Associate.—Arthur Bennett.

Withdrawn.—James Robert Ainslie, William Jenkins Webb Anderson, Charles James Bamber, Robert Crookall, James Davidson, Walter John Dowson, Wellington Ernest Groves, Edward Heron-Allen, Thomas Johnson, Hugh Godfrey Mundy, Narayanan Padmanabha Panikar.

Removed.—Robert Barr, Frederick William Cousens, Edwin Percy Phillips.

On the 14th March, 1929, His Royal Highness The Prince of Wales graciously honoured the Society by becoming an Honorary Member, and signed the Signature Book on the 26th March, 1929. During the Session and including the Anniversary Meeting forty-one Fellows, three Foreign Members, and one Associate were elected. Of the forty-one Fellows, twenty-nine have qualified. Five Fellows elected during the Session of 1927–28 have also qualified, making a total of thirty-four new names for the List. Deducting from this the twenty-seven names of Fellows that disappear from the List, the net addition to the number of Fellows is seven. The numbers on the List of the Society at present are as follows, including as Fellows only those who have qualified by paying their Admission Fees or Annual Contributions, or both as the case may be :—

	Men.	Women.	Total.
Honorary Members	2	1	3
Fellows	660	118	778
Foreign Members	50	—	50
Associates	23	1	24
Totals	735	120	855

Assuming that all Fellows elected during the Session of 1928–29 will qualify before the Session 1929–30 begins, it will require only a net gain of ten Fellows during the next Session to bring the Fellowship of the Society up to eight hundred, the full number as at present determined.

ADMISSIONS.—The number of Fellows admitted during the Session is, including those admitted on the 24th May, 1929, thirty-one.

PUBLICATIONS.—During the year four numbers of the Society's Journal appeared, two botanical and two zoological, comprising five botanical and five zoological papers. Vol. xxxvi. of the Journal (Zoology) was completed. There are in the press two botanical numbers containing four papers and four zoological numbers, containing nine papers.

LIBRARY.—The direct expenditure on the Library from the 1st May, 1928, to the 30th April, 1929, was £1482 1*s.* 10*d.*, including the second moiety, amounting to £666 13*s.* 4*d.*, of the grant from the Carnegie United Kingdom Trustees. The amount directly spent on the Library during the last two years exceeds the total amount spent during the first eighty-eight years of the Society's existence. During the year 520 works have been purchased and 236 books and reprints presented, making a total of 756 additions. The number of volumes bound was 1595. The additions enumerated above do not include current periodicals, of

which the Society obtains 396 by exchange, 167 by gift, and 87 by purchase.

Between the 1st May, 1928, and the 30th April, 1929, 1250 volumes were borrowed by 162 Fellows and Associates, or roughly about one in four of Fellows and Associates resident in the British Isles. In addition the Central Library for Students borrowed 62 volumes. The Society borrowed on behalf of Fellows and Associates 4 volumes from the Science Library, which are not included in the 1250 volumes mentioned above. During the same period 1125 signatures—including 49 on Saturday afternoons—were recorded in the Library Visitors' book by 221 individual visitors, including 24 on Saturday afternoons. It is probable that the signatures in the Visitors' book represents only a proportion of the Fellows and Associates who visit the Library. The general routine work of the Library was carried on as usual, and, in addition, valuable help was given by Mr. A. W. Sheppard, who catalogued all the additions to the Library and prepared the lists of additions which are now periodically printed in the reports of the General Meetings. He also collated several hundreds of volumes of periodicals, sets of which for various reasons were incomplete, and a considerable number of such sets were completed. The collection of General Hardwicke's drawings of Indian animals and the extensive sets of paintings of the collection of animals which Lady Impey, the wife of the Chief Justice of Bengal in the time of Warren Hastings, possessed at Calcutta have been carefully cleaned by Mr. Sheppard and placed in Solander cases. Mr. James Robson, another volunteer, prepared an alphabetical list of the periodicals received in the Library, which it is hoped may be printed ere long, and also prepared an index of all the papers read at the General Meetings for the last fourteen years.

LINNEAN COLLECTIONS.—Attention was given to the better preservation of these collections. The Library of Linnaeus is being systematically examined, such books as require repair are receiving it and, where necessary, are being placed in protecting cases. Steps are also being taken under the supervision of Dr. W. T. Calman to ensure the better preservation of the zoological collections. A collection of Linnean Theses, hitherto loose, have been bound into thirteen volumes, with the advisory assistance of Dr. R. T. Gunther.

STAFF.—Although the strength of the staff is still below what it was over forty years ago, the advent of an Office boy has relieved the senior members of many of the less severely intellectual items of their duties. Mr. Spencer Savage rendered his customary devoted service to the Society, and Mr. W. S. Warton performed the ordinary work of the Library with his usual competence.

GENERAL.—Circumstances at present under consideration have led the Assistant Secretary to survey the financial vicissitudes of the Society, and he has prepared tabulated statements showing year by year from 1788 to 1929 the receipts and the expenditure of the Society under the appropriate subheads. This has entailed a good deal of labour, but it should henceforth be a simple matter to continue the tabulation for future years, and it is hoped that the tabulation may prove instructive and interesting to present and future officers in charge of the Society's welfare. Details cannot be given here and now, but a few of the main results are presented. Since 1788 to the 30th April, 1929, the Society has received nearly £220,000. Of this sum Annual Contributions account for over £114,000, Composition Fees nearly £29,000, Admission Fees over £18,000, Sale of Publications nearly £22,000, Special Subscriptions, Donations, Grants, and Bequests over £19,000, and Miscellaneous over £17,000.

The total expenditure for the period of 141 years is over £208,000, of which £81,000 have been expended on Publications, £50,000 on pay of Staff, £20,000 on the Library, nearly £14,000 on Rent, Rates, Taxes, and Insurance, and the remainder, including the purchase of the Linnean Collections from the Executor of Sir James E. Smith, on miscellaneous items. The £20,000 expended directly on the Library is merely the cash expenditure, and a proportion of the £81,000 spent on publications should really be added to it as representing the value of the Library additions gained by exchange of publications.

At the conclusion of the Assistant Secretary's report, the PRESIDENT appointed Mr. Stanley Edwards, Mr. H. N. Ridley, and Lt.-Col. J. H. Tull Walsh as Scrutineers of the Ballot.

The President then read the following account of the scientific work of Professor Hugo de Vries, to whom the Linnean Gold Medal had been awarded, and thereafter handed the Medal to Dr. J. B. Hubrecht, Counsellor of the Netherlands Legation, for conveyance to Professor de Vries, who was unable to be present:—

The Council on behalf of the Society have this year selected Professor Hugo de Vries as the recipient of the Linnean Medal, the Society's highest award, given to him as an expression of its estimate of the conspicuous value of his contributions to Biology.

In 1870 Professor de Vries published his thesis on the influence of temperature on plants; and for nearly sixty years a steady and constant stream of fundamental results has been achieved by an unusual combination of energy and acumen. For about the first twenty years he worked mainly on the physiological problems concerned in plant-growth. To this period belongs the classical work on osmotic pressure, which, together with that of Pfeffer, led to the generalisations of Van t'Hoff. The methods devised by him for comparing osmotic pressures by the use of living cells or tissues are still in general use in botanical labora-

tories. De Vries's physiological work was extremely wide in scope, including such different aspects as the permeability of protoplasm, the formation of annual rings, and the special physiology of agricultural crops, particularly beet and potatoes. At the end of this period (1890) he published the results of his ecological study of the animals and plants inhabiting the channels of the Rotterdam water-supply, calling special attention to the serious consequences which may follow an invasion of Iron-Bacteria.

From 1889 onwards de Vries directed his researches to the problems of variation and heredity. His theory of intracellular pang-nesis, first published in 1887, involved a modification of Darwin's conception of pangenesis, and was the first of its kind which assumed material particles as bearers of hereditary characters. It had a great clarifying effect in developing the first part of Darwin's theory, which postulated numberless particles representing the individual cells; and in eliminating the second part, the throwing off from the cells of particles which accumulate in the germ-cells, which had been introduced to account for the inheritance of acquired characters. The theory has served as a foundation for subsequent speculations on the mechanism of heredity and on the structure of the germ-plasm; and the present conception of the gene is the lineal modernised descendant of these early views.

De Vries may be regarded as the first of the experimental evolutionists. He re-discovered the segregation of characters, learning of Mendel's work only after the close of his own experiments. His Mutation Theory, 1901–1903, was based on many years of experimental breeding, especially of *Œnothera*, in which he introduced the pedigree method and developed the mutation theory of the origin of species. This work has rightly been regarded as the most important advance in evolutionary theory since Darwin. The numerous developments which have taken place in genetics and in cytological research have served to emphasize its importance. De Vries has, moreover, continued to be an active leader in genetic investigation till the present time. His 'Gruppenweise Artbildung' (1913) recorded the most intricate and extensive series of breeding experiments which had been published on any group of plants or animals.

The scientific contributions which de Vries published in various journals were re-issued in seven large volumes in 1927. In addition to this enormous output he has expounded the popular side of his work in numerous writings, with the result that the name of Hugo de Vries is as well known to the general public of his own country as it is to Biologists in every part of the world.

Dr. J. B. Hubrecht, on behalf of Professor de Vries, thanked the Society for the Medal and the President for his kind words.

[In the introductory passage of his Address the President announced the retirement of Lieutenant-Colonel A. T. Gage,

C.I.E., F.L.S., from the position of Librarian and Assistant Secretary, and the appointment as his successor of Mr. Spencer Savage, known to Fellows of the Society for so many years as the able assistant, in succession, to the late Dr. Daydon Jackson and to Lieut.-Col. Gage.

The Fellows present indicated their warm agreement alike with the President's thanks to Colonel Gage and with his welcome to Mr. Savage.]

The President delivered his Address on "Polyzoa" [see page 68].

On its conclusion Dr. D. H. Scott, F.R.S., moved "That the President be thanked for his excellent Address, and that he be requested to allow it to be printed and circulated amongst the Fellows." The motion was seconded by Dr. A. B. Rendle, F.R.S., and being put to the Meeting was carried with acclamation.

The Scrutineers of the Ballot, who had retired at the appointed times with the voting-lists for the election of the Council and of the Officers, having completed their scrutiny, reported to the President, and he declared the result as follows :—

Council for 1929–30.—Dr. G. P. Bidder; Mr. I. H. Burkill; Dr. E. J. Butler, C.I.E., F.R.S.; Major T. F. Chipp, M.C.; Dr. E. J. Collins; Mr. G. R. de Beer; Mr. H. N. Dixon; Mr. Francis Druce; Dr. Philippa C. Esdaile; Professor R. R. Gates; Professor E. S. Goodrich, F.R.S.; Sir Sidney F. Harmer, K.B.E., F.R.S.; Dr. A. D. Imms, F.R.S.; Miss Gulielma Lister; Mr. G. W. E. Loder; Mr. H. W. Monckton, V-P.G.S.; Mr. John Ramsbottom, O.B.E.; Dr. C. Tate Regan, F.R.S.; Dr. E. S. Russell; Professor E. J. Salisbury.

(The retiring Councillors were Dr. W. T. Calman, F.R.S., Mr. A. D. Cotton, Professor J. Stanley Gardiner, Professor D. L. Mackinnon, and Professor John Percival.)

Officers for 1929–30.—*President*: Sir Sidney Frederic Harmer, K.B.E, F.R.S.; *Treasurer*: Mr. H. W. Monckton, V-P.G.S.; *Zoological Secretary*: Dr. G. P. Bidder; *Botanical Secretary*: Mr. John Ramsbottom, O.B.E.

The President then announced that he appointed the following as VICE-PRESIDENTS for 1929–30:—Dr. E. J. Butler, C.I.E., F.R.S.; Professor E. S. Goodrich, F.R.S.; Miss Gulielma Lister; Mr. H. W. Monckton, V-P.G.S.

Thereafter the President declared the Session of 1928–29 closed.

PRESIDENTIAL ADDRESS,

24th May, 1929.

By Sir Sidney F. Harmer, K.B.E., F.R.S., Sc.D., P.L.S.

(With 11 Text-figures and Plate I.)

The Session which is just closing may be described as a very successful one. The papers read at our General Meetings have included several of special interest, and I think they have demonstrated the advantage we possess in representing the whole range of Natural History. From my own experience during the year I can assert that Zoologists have found much to interest them in the communications of their Botanical colleagues: and I hope I may assume that our Botanists have listened with pleasure to some of the Zoological communications.

The short list of Honorary Members has been increased by the addition of the name of His Royal Highness The Prince of Wales, who graciously consented to join the Society in this capacity during the Session which is past. This event has afforded special gratification to the Fellows.

I am sorry to have to inform you that Colonel Gage has announced his intention to resign the office of Librarian and Assistant Secretary on Oct. 31st next. In his capable hands our affairs have been managed with conspicuous tact and discretion. I feel confident that I shall express the general feeling by saying that we are greatly indebted to him for the services he has rendered to the Society in its corporate capacity, as well as for the personal assistance he has given to many of us, and that we shall part from him with great regret.

The Council have given careful consideration to the question of filling the vacancy which will thus be caused. They decided that the best interests of the Society would be served by offering the appointment to our present Clerk, Mr. S. Savage, who has given devoted service for many years and is specially qualified to undertake the duties of the post by his intimate acquaintance with all branches of the Society's work, and in particular by the knowledge he has acquired of the Linnean Collections. It has been further decided by the Council that in order to provide room for the expansion of the Library, and for other reasons, it will be advisable to give up the use of the upper floor as a residence; and the appointment has been accepted by Mr. Savage on this understanding.

The general progress of the Society during the year has been satisfactory, as is shown by the fact that the roll of Fellows, now fixed at 800, is nearly complete. We have been glad to welcome among our newer recruits many who have joined the Society at an age when the most fruitful period of their scientific lives is presumably still to come.

The Society has honoured itself by electing three distinguished Foreign Members:—Dr. Theodor Mortensen, Professor Carl Hansen Ostenfeld, and Professor Bohumil Němec.

The Obituary Notices to be published in the 'Proceedings' will record the death of naturalists of distinction. Among those whose loss we mourn I may specially mention, among our Fellows, Mrs. Scott, the wife of Dr. D. H. Scott, President 1909–1912; Sir William Thiselton-Dyer, Mr. R. H. Cambage, Mr. Thomas Scott, and Mr. A. W. Waters; and, among our Foreign Members, Professor V. F. Brotherus, Professor J. M. Coulter, and Professor J. W. E. G. Leche.

The Hooker Lecture was delivered, on March 14th last, by Dr. E. J. Allen, F.R.S., who took as his subject "The Origin of Adaptations."

Steps are being taken for the better conservation of parts of the Linnean Collection which required attention, and for the improvement of the ventilation of the Meeting Room.

The liability of the Linnean Society with regard to the payment of Income Tax on the proceeds of its investments has occupied the special attention of the Council; but, like other Scientific Societies, we are still uncertain as to the outcome of the efforts which have been made to obtain relief.

The Library has been augmented by many valuable works which have been purchased out of the generous gift of £2000 made by the Carnegie United Kingdom Trust. One third of this amount has been received during the current Session.

I desire to call the special attention of all who are interested in the Society to the existence of the Goodenough Fund, which was founded "to enable the Council to pay the Admission Fee or Annual Contribution of one or more Fellows of the Society who are deserving of this assistance." The details of distribution are not published. It unfortunately happens with some frequency that Fellows are compelled by alteration of their circumstances to withdraw from the Society. Contributions to the Capital of this Fund would be welcomed by the Council, and would be most useful in helping to avoid the necessity of accepting the resignation of Fellows whom the Society would wish to retain on their list.

In deciding the subject on which to address you in more detail I felt that I could not do better than to select the group of animals to which I have devoted most of my time available for scientific research. Many of the facts I mention will be familiar to workers in the same field, and for this I must ask their indulgence. It is necessary to adopt this procedure if I attempt to find matter of general interest. My Address, which follows, deals partly with the work of early observers and partly with certain recent contributions to knowledge.

POLYZOA.

I. Introduction.

The Presidential Chair of the Linnean Society was occupied, from 1874 to 1881, by Professor George James Allman, who

devoted his Presidential Addresses of 1878 and 1879 to the consideration of recent progress in the knowledge of the freshwater and marine Polyzoa, a subject on which he was an acknowledged authority. I follow the example of my distinguished predecessor in inviting the Society to give its attention for a short time to this group of animals, and I wish first to acknowledge the special debt of gratitude which I owe to him. The acquaintance I made, in early years, with his admirable and beautifully illustrated 'Monograph of the Freshwater Polyzoa' (1856) awakened the almost life-long interest which I have taken in these remarkable and beautiful creatures.

I should fail in my duty if I did not at the same time acknowledge my indebtedness to two other Fellows of the Society—George Busk and Arthur William Waters. Mr. Busk was Secretary from 1857 to 1869, and the value of his work on the Polyzoa is so universally recognized that no words of mine are required to emphasize its importance. Mr. Waters, whose recent death we deplore, had been a Fellow for more than fifty years (since 1876). He had devoted the greater part of a long life to this group, on which he had written many systematic papers. He was one of the few naturalists who have had an intimate acquaintance, not only with the recent species of Polyzoa, but also of their fossil allies; and a record of his work will be found, among the Obituary Notices, on p. 149 of the present issue of the 'Proceedings.'

The Polyzoa are sedentary colonial animals which are found principally in the sea and are also a constituent of the freshwater fauna. The body-wall is often well calcified, and the group is thus abundantly represented by fossils, the earliest of which flourished in the Palæozoic Period. Many are objects of singular beauty when examined with slight magnification under a microscope.

I do not discuss here the vexed question of the affinities of the Polyzoa. Many opinions have been expressed on this subject, but I may state my conviction that it is not possible to associate them closely with any other group, and that they should accordingly be given the rank of a Phylum. They are not readily placed in any evolutionary series, and they have, in fact, branched off on a distinct line of their own. They thus occupy a backwater which has, perhaps, not been explored with the attention it deserves; but they possess remarkable characteristics which should make them objects of special interest to both morphologists and physiologists. They have evolved, for instance, a unique want of conformity between the body-wall and the organs it contains; so great, in fact, that each unit of the colony was at one time supposed to consist of two individuals of different kinds. The "polypide," which was defined by Allman (1856, p. 8) as "the retractile portion of the Polyzoa," was considered by him (pp. 41, 42) to represent a distinct kind of zooid, and this view was accepted and developed further by Nitsche (1871, pp. 479, 480). The retracted polypide is contained in the body-wall, which is known as the "zoœcium'

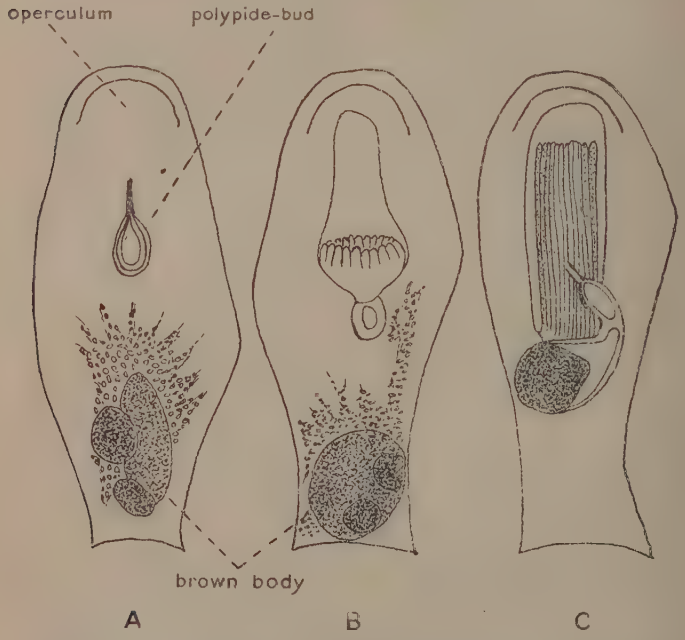
(Smitt, 1865, p. 115), or the house of the zooid; and the conception that this is an individual of a different kind was emphatically maintained by Nitsche. These names are so firmly established in the literature of the Polyzoa that it seems to me undesirable to attempt to replace them by others (as has been done by various authors), even though they at one time implied a morphological idea which is no longer current. It is now generally considered that the development of a series of polypides in a zoœcium does not involve the acceptance of a theory of units composed of dimorphic individuals.

The life of the polypide, which consists of the whole of the alimentary canal, the ciliated tentacles, the tentacle-sheath which encloses them when retracted, and the central nervous system has a very limited duration. All these parts degenerate after a time, and become consolidated into a compact spherical or ovoid structure known as the "brown body," which either remains as an inert mass in the zoœcium or is evacuated (text-fig. 1, p. 72). The loss of the entire alimentary canal, with the tentacles and tentacle-sheath (the food-collecting apparatus), and of the central part of the nervous system, is, however, of no moment, since these structures are shortly replaced by a new polypide, formed as a bud inside the zoœcium. This is a normal occurrence in most of the Polyzoa. It may take place several times in the life of a zoœcium, where a record is sometimes left, as a number of brown bodies indicating a corresponding number of degenerations. The formation of brown bodies is perhaps to be regarded as an excretory process, in the absence of specific excretory organs.

In their embryonic history the Polyzoa are no less remarkable. With the exception of a few species, which probably retain a primitive character in this respect, the larva develops no alimentary canal, and its endoderm is recognized with difficulty. In the rare cases where a functional alimentary canal is present the larva (*Cyphonautes*) is able to feed, and it behaves as a pelagic organism. In the great majority of species the larva, which swims freely for a time by means of its cilia, must depend for its nutrition on its accumulated store of yolk. There is evidence, in some instances, that it takes the first opportunity it finds of attaching itself to some suitable object, after a free life of extremely short duration. It then rapidly undergoes its metamorphosis into the first individual ("ancestrula") of the future colony, which is produced from it by a process of budding. No case is known in which the embryonic endoderm gives rise to the first or to any other alimentary canal, throughout the Ectoprocta. The whole of the new polypide is developed from a polypide-bud, which soon after its first formation has the form of an ovoid two-layered vesicle lying in the body-cavity. The two layers have been developed from the ectoderm and mesoderm respectively of the body-wall; and, as the vesicular form is produced by a process of modified invagination, it is the inner layer which is formed by the ectoderm. This inner layer assumes in part the character of a normal

endoderm, inasmuch as it gives rise to the whole of the epithelial lining of the alimentary canal: but, in addition, it produces the ectoderm of the tentacles and of the invaginated tentacle-sheath, as well as the central ganglion of the nervous system. Throughout the Ectoprocta, the principal subdivision of the Polyzoa, the polypide-bud behaves in this manner, whether it is formed in the metamorphosed larva, in a young zoœcium which is developing its first polypide, in an old zoœcium regenerating after the

Fig. 1.



Regeneration in Cheilostomata (*Flustra papyrea*). In A a polypide has degenerated and consists of three parts, which are surrounded by mesoderm cells; a two-layered polypide-bud has appeared. In B the brown body is more compact, and the polypide-bud has developed tentacles and alimentary canal. C, commencement of the passage of the brown body into the stomach of the new polypide.

formation of a brown body, or in a germinating statoblast. The statoblasts are internally produced masses of tissue, generally regarded as internal buds, which are restricted to the Phylactolæmata, a freshwater group. They are protected by a chitinous shell, and in temperate latitudes at any rate they generally remain dormant during the winter and germinate in the succeeding spring.

These facts are sufficiently remarkable to be of great morphological and physiological interest, but there is another which is particularly noteworthy. There is a good reason for believing that throughout the Cyclostomata the egg never develops into a single individual, but always gives rise to a multitude of embryos by successive fissions of a "primary embryo." Some of the details of this remarkable process are given below, in Sect. VI. (*c*).

The largest order of recent Polyzoa, the Cheilostomata, is of special interest, by reason of the occurrence, in the majority of its species, of a striking dimorphism or polymorphism of the zoœcia, some of which undergo an extraordinary modification into the structures known as avicularia or vibracula. Many species illustrate the manner in which this evolution appears to have been carried out. An avicularium may take the place of an ordinary zoœcium, being then described as "vicarious," and in a few species it possesses a functional polypide. Its operculum is always different from those of the normal zoœcia, and is distinguished as the "mandible." In their later evolution the avicularia ceased to occupy the place of a zoœcium, and became "adventitious." They now appear as appendages, variously situated, of the zoœcia, commonly in the neighbourhood of the orifice, but sometimes far removed from it, as in the cases where they are found on the basal side of the zoœcia. They may be large or small, with mandibles of multiform shapes. In their most differentiated form they are stalked and mobile and they have a striking resemblance to the heads of raptorial birds. The lower jaw of the bird is closely imitated by the mandible, which can be closed by powerful muscles. The avicularia are not merely objects of interest to an observer who is fascinated by watching their movements on the colony and the opening and closing of their prehensile jaws, but they are of great importance in the definition and recognition of species. The vibracula appear to be individuals which have had a similar evolution, but in this case with the reduction of the zoœcial part and the prolongation of the operculum into a long whip-like structure, which is moved by suitable muscles. The movements of the numerous vibracula of a colony are occasionally co-ordinated (*Caberea*). Both kinds of individuals are almost certainly in some degree protective, and I have previously suggested that some of the enemies whose unwelcome attentions they specially discourage are the larvæ of Polyzoa and other organisms which would otherwise develop into crusts on the surface of the possessors of the avicularia, and thus prevent them from taking food and carrying out other vital functions.

II. Economic Importance of Polyzoa.

My subject is mainly of academic interest, and the student of Polyzoa seldom finds himself in touch with matters of economic importance. There is, however, at least one notable exception to the above statement—the remarkable story of the fauna and flora of the pipes of the waterworks of towns.

(a) *Biology of Waterworks.*

The first noteworthy ecological study of this subject was made by Kraepelin (1886), who demonstrated by his investigation of the water-supply of Hamburg that it is essential to filter water before admitting it to the supply-pipes. In the absence of filtration, two things can happen. The water may become populated by immense numbers of Diatoms and other microscopic organisms; and, from time to time, the eggs or larvæ of animals which feed directly or indirectly on these unicellular creatures will also obtain an entrance. If these two events occur, microphagous animals, particularly Polyzoa and Sponges, may flourish amazingly, not being averse to living in the dark, and probably deriving some advantage from their security from extreme vicissitudes of temperature. The microphagous animals in their turn provide food for other creatures. Crustacea, such as *Asellus* and *Gammarus*, may occur in hundreds of thousands in the underground system. The water-supply may, in short, become inhabited by a profuse assemblage, consisting principally of unicellular plants, Protozoa, Polyzoa, Sponges, Oligochæta and other worms, Crustacea, Molluscs and Fishes, some of these organisms being found in almost incredible numbers. The Polyzoa and other fixed animals become detached when they die, so that they are carried into the circulation, and not only block the pipes, but, by their decomposition, encourage the growth of Bacteria. Hamburg has been by no means unique in this experience, in the absence of effective filtration. Another similar instance, at Rotterdam, was investigated by de Vries, to whom we have just had the honour of awarding the Linnean Medal. I had myself the opportunity, some years ago (1913), of recording several cases where serious trouble of the same kind had occurred in British water-supplies, and I mentioned the more important earlier papers on the subject, particularly those of Kraepelin, de Vries, and Kemna. I referred there to the possible serious results of the infection of a water-supply by animals which are themselves innocuous, as shown by the history of the severe cholera epidemic which occurred at Hamburg in 1892. In practically all the recorded cases in which trouble of any kind has been experienced the Polyzoa have been the principal offenders, and a remedy has been found by the institution of an effective system of sand-filtration, which cuts off their microscopic food. The practical importance of this subject and its ecological interest have been recognized by the Trustees of the British Museum, who have published a special Guide-book, 'The Biology of Waterworks' (1917), written by Mr. R. Kirkpatrick.

(b) *Fossil Polyzoa.*

The calcareous Polyzoa have proved well suited for preservation as fossils, and there is a very large amount of literature dealing

with this part of the subject. The Palæozoic Period was characterized by numbers of species belonging to two orders, the Trepostomata and the Cryptostomata, both now extinct with the possible exception of one or two recent genera. During the Secondary Period the Cyclostomata became specially numerous and occurred in a great variety of forms, the Cheilostomata being also represented in considerable numbers. In the Tertiary Period the Cyclostomata are less frequent, and the Cheilostomata have become the dominant group. I do not propose to enlarge on this subject, but it is evident that many of the geological formations are well characterized by their Polyzoa. It is probable that with increasing knowledge this phylum will become more important than at present as a means of correlating the age of strata, and that the assistance of students of the group will be more sought in connexion with economic problems in Geology. Much work on the genera and species will be required before full use can be made of this promising material.

(c) *Polyzoa and Materia Medica.*

The Polyzoa are not commonly used for any practical purpose, but there is reason to suppose that the skeletons of certain calcareous species may have been employed in classical and mediæval times as drugs.

The 'Historia Naturale' of Imperato, originally published in 1599, contains one of the earliest known accounts of the Polyzoa. Chapter III. of Liber XXVII. is entitled "Pori e loro differenze" (1599, p. 715; 1672, p. 624); and "Pori" are defined as vegetables composed of a substance like that of coral, from which they differ in their porosity. The familiar names *Retepora* and *Frondipora*, which have passed into current use as recognized genera of Polyzoa, appear here for the first time, and Imperato also described *Millepora*, *Madripora*, and *Tubulara*, the last the familiar organ-pipe coral. The example thus set in the construction of names has been repeatedly followed by the introduction in zoophytology of numerous genera with the termination *-pora*. Amongst these "Pori" there is one which was figured by Imperato (1599, p. 725; 1672, p. 632) with the heading "Poro anguino, altrimente Adarce," and the locality "nel mar morto, sotto Baia" (Pl. I. fig. 1). On p. 45 of the 'Elenchus Zoophytorum' of Pallas (1766) *Porus anguinus* is given as the first synonym of a new species, *Eschara spongites*, which is also identified with the *Lapis spongiæ* of the shops. *Adarce* is referred to by Pallas (p. 273) as the name given by Dioscorides to an encrustation found round reeds in marshy places in Cappadocia; and in the "Addenda" (p. 433) *Adarce* of Mercati is given as a further synonym of *E. spongites*. In Mercati's work, Chapter XIII (1719, p. 112) deals with *Adarce*, also known as *ἀδάρκη*, Adarca of Pliny, and Adarchi with other variants of old Arabic authors.

The indication given by the heading of Imperato's figure that his "Poro anguino" is the *Adarce* known to classical writers as a substance having medicinal virtues seems to be worth following further. I think I am able to show that the nature of Imperato's organism has been consistently misunderstood by almost all later authorities, and that the correct appreciation of what it really is may help to explain certain classical allusions to *Adarce*.

So many writers have quoted Imperato that I find it difficult to believe that none of them has understood his meaning. I can merely say that I have been unable to find a correct interpretation of his figure, which is unquestionably a representation (natural size) of the marine flowering-plant *Posidonia oceanica*, partially surrounded by a calcareous encrustation. This has the form of a fairly thick-walled tube, represented as from 3 to 4 inches in length and nearly an inch in diameter. The strap-like leaves of the *Posidonia* project from the upper part of the tube, and the lower part of the figure shows the bases of its old leaves, with numerous long fibres diverging from the stems and surrounding or being partially surrounded by the calcareous tubes. These fibres are a specially characteristic feature of *Posidonia*, and they have been well described, as follows, by Read and Smith (1919), a reference which I owe to Dr. A. B. Rendle:—"Marine fibre" is the name given to the fibrous portion of the leaf-sheath of *Posidonia*. Each fibre is a bundle of numerous elongated woody cells, which run longitudinally up the substance of the leaf, under the epidermis. When the plant is dead and detached from its substratum the fibres of its disintegrated leaves become felted by wave-action into round balls, which are common objects of the sea-shore of South Australia, to which Read and Smith's account refers, as well as in the Mediterranean. The balls vary in size up to a diameter of several inches, frequently resembling the fæcal masses of a horse, both in size and appearance; and their nature has puzzled many naturalists, ancient and modern. They were apparently referred to as "*Balla marina*" by Imperato (1672, p. 637), who stated that they are formed by the "rotulamento dell' acqua marina," but expressed no opinion as to their nature. They were described as "*Pila marina*," "*Sphæra marina*," and under other names by Faber (1692), who supposed that they might be the excrement of an "equus marinus," perhaps a hippopotamus, or that they were possibly formed in the stomachs of fishes.

In a later paper (1694) Faber identified the *Lapis spongiæ* with the *Adarce* of ancient writers, and noted that it almost always occurs on fragments of the *Pilæ marinæ*. The description given on pp. 199, 200 of his memoir can be recognized as referring to *Posidonia*. This paper, with others, is quoted by Wilkens and Herbst on pp. 77, 78 of the German edition of the 'Elenchus' of Pallas (1787), published by them with numerous additions to the original text. The medicinal properties of *Adarce*, as described by Dioscorides, Avicenna, and Galen, did not appear to them to

PORO ANGVINO, ALTRIMENTE ADARCE, si concrea nell' acque salse oue sia il mar quieto, d' intorno l' alga, & altri corpi si ritrona appo noi nel mar Morto, sotto Baia.

Porus Anguinus cruciaceus tubulatus capsulis minimis ex Museo N. Gualtieri n.° 55

Nanebuoni del. — D. Cyrill. Sculp.

correspond with those of the *Lapis spongiæ*, and they were accordingly doubtful whether the two substances are identical.

The occurrence of these *Pilæ marinæ* on the shore is a good indication that *Posidonia* is growing in the adjacent waters; and they are common, like the living plant, in the neighbourhood of Naples, the type-locality of Imperato's "Poro anguino."

It is perhaps possible, as Imperato appears to have supposed (unless *Adarce* had survived as a vernacular name), to read into some of the accounts given by classical writers a specific reference to an organism identical with the "Poro anguino." My friend Prof. D'Arcy W. Thompson has kindly enabled me to trace Mercati's allusion to Pliny, who mentions *Adarca* in the following passages:—

XVI, 671. "est et in Italia palustris ex cortice tantum sub ipsa coma nascens, adarca nomine, utilissima dentibus, quoniam vis eadem est quae sinapi."

XX, 241. "Sinapis naturae esse effectusque eosdem habere traditur adarca inter silvestria dicta, in cortice calamorum sub ipsa coma nascens."

XXXII, 140. "Inter aquatilia dici debet et calamochnus, Latine adarca appellata. Nascitur circa harundines tenues e spuma aquae dulcis ac marinae, ubi se miscent. Vim habet causticam, ideo acopis utilis et contra perfrictionum vitia."

In order to avoid the possibility of being led astray by a mistranslation, I obtained the following rendering of the first passage from a classical friend:—

> "There grows in Italy a certain thing, by name adarca, in marshes, out of the rind but under the hair itself, most useful for the teeth, because its force is as that of mustard."

Combining these passages it thus appears that *Adarca* grows round reeds in Italy, and that it may be marine. I understand from Professor Thompson that there has hitherto been no satisfactory explanation of "sub ipsa coma," words which had specially interested me. I venture to suggest that this part of the description refers to the characteristic hairs of *Posidonia*, partially overlapped by the encrustation, *Adarca*, which grows out of the rind of the "reed." The plant is so common on Mediterranean beaches that it and its investment of Polyzoa may well have been familiar to Pliny, who had probably found it in the vicinity of Naples. If this is considered a plausible interpretation, it may be claimed that definite references to the Polyzoa are apparently to be found in classical or Arabic writers.

The statement that *Adarce* may occur in fresh water does not raise any serious difficulty. It is well known that the stems of genuine reeds, growing in marshy places, are often surrounded by an encrustation, presumably calcareous, near their bases; and the fact has been mentioned by more recent writers. Such deposits, due to the evaporation of water containing salts in solution, are

likely to have been supposed to be of the same nature as the encrustations formed by marine animals. The "Poro anguino," as described below, seems to be more suitable, from its consistency and its amount, for the preparation of tooth-powder than the inorganic freshwater deposits which, so far as I know, are comparatively thin films.

The *Poro anguino* of Imperato has usually been identified with *Eschara spongites* Pallas—the *Schizoporella spongites* of modern systematists. I feel justified in asserting, however, that *S. spongites*, as generally understood, is not Imperato's species, the original description of which runs as follows:—

> "Questo è consistenza appresa d'intorno le radici di alga, ò di altra simil materia, e quasi incrustatura composta di molte, e sottilissimi spoglie, de quali l'una veste l'altra, simili per la condizion del colore, sottigliezza, & impressioni, delineamenti à spoglie de serpi; è sustanza porosa, e molto fragile per la strema sottigliezza delle tuniche, di color bianco, & ove l'una tunicha dall'altra si separa di splendidezza argentina" (1599, p. 716; 1672, p. 625).

Poro anguino is thus a white encrustation, attached to the roots of algæ or other similar bodies, and is composed of many delicate superposed skins which in their delicacy and markings resemble a serpent's skin. Where one tunic separates itself from another it is of silvery splendour.

Imperato here gave an excellent description of the common Mediterranean species which has usually been known as *Micropora impressa* (Moll, 1803). It is a curious fact that Pergens (1887, p. 17) has been almost alone in noticing that Moll's trivial name is antedated by *Cellepora nobilis* Esper (1796). Esper gave good figures, corresponding closely with that of Imperato, and showing the overlapping of the older layers by the thin growing lobes of younger layers, as described by this author. He stated, moreover, that his species grows round an unknown plant-stem. *C. nobilis* is now placed in the genus *Calpensia*.

The proof of the identity of Imperato's species is not complete, however, unless it can be established that *Calpensia nobilis* is to be found as a multilaminar encrustation round the stems of *Posidonia* occurring near Naples. Although I had myself obtained it there in 1891 in the condition thus indicated, I had merely preserved small fragments (now in the University Museum of Zoology, Cambridge) which were hardly sufficient to establish my point. In my search for better evidence I have been assisted by various friends, among whom I may specially mention Dr. R. Dohrn, Mr. E. E. Berry of Bordighera, and Dr. G. H. Carpenter.

The necessary proof was ultimately found in the collection of Mr. A. W. Waters, a Fellow of this Society recently deceased (see p. 70). Mr. Berry had received an intimation of the fact (since published) that Mr. Waters' large collection had already reached the Manchester Museum, to which it had been bequeathed;

and he wrote to Dr. Carpenter, who kindly lent me two dry specimens, labelled "*Micropora impressa* Moll, Naples, 1879." The longer one is a tube open at both ends and almost $3\frac{1}{4}$ inches long. At one end, which I judge to be the lower, the tube is compressed, $1\frac{3}{8}$ inches in its longer diameter and $\frac{3}{4}$ inch in its smaller diameter. The opposite end is circular in section, $\frac{5}{8}$ inch in diameter. The wall of the tube is rather more than $\frac{1}{4}$ inch thick at the lower end, where 16 superposed laminæ can be counted; and it is considerably thinner at its upper end, where the laminæ are less numerous. The shorter specimen is more irregular in shape, and one end is rounded and completely closed, probably implying that it had grown over the dead end of a stem which had ceased to grow. In both specimens the younger laminæ show some indication of the silvery appearance mentioned by Imperato—a condition which is more obvious in the specimens collected by me at Naples in 1891. The zoœcia have an arrangement justifying Imperato's comparison with the surface-markings of a serpent's skin, and the loose attachment of the laminæ to one another recalls a snake in process of shedding its old skin. .

The objects round which Mr. Waters' specimens were formed have not been preserved; and in this single point my proof is incomplete. I am confident, however, that these colonies had encrusted the stems of *Posidonia*, a conclusion based on my recollection of material which I have myself found on Mediterranean beaches.

The description given by Pallas of *Eschara spongites* shows that several species were included by him under this name. In the diagnosis, "lamellis simplicibus undulato turbinatis cumulatis," the last two words clearly refer to the species usually known as *Schizoporella spongites* (Pl. I. fig. 2), to which the "bullulæ" [ovicells] mentioned in the more detailed description also belong*. The species was said by Pallas to be often multilaminar, and this refers to *Calpensia nobilis*, as is shown by his citation of Imperato. The American specimens included probably belonged to other species.

In addition to *Porus anguinus* (the first synonym) Pallas gave the following synonymy:—

Mercati ('Elenchus,' Addenda, p. 433), who figured four specimens which are quite unmistakably *Calpensia nobilis* growing round stems of *Posidonia*. On p. 111 the same author also described *Pila marina*, "Graeci *σφαιραν θαλασσιον* nominant," suggesting that these objects are fragments of marine plants.

Besler Museum. The unsatisfactory figure of *Lapis spongiæ* may represent an incomplete tube of the same species.

Gualtieri, who gave an excellent figure (reproduced here in a reduced size on Pl. I. fig. 2). The original figure is about

* Ovicells are usually stated to be absent in *Calpensia*, but an ovicell was figured by Heller, perhaps by mistake, in *Membranipora bifoveolata*, which is usually regarded as a synonym of *Micropora impressa* auctt. (see Harmer, 1926, p. 308 *n.*).

9 inches high, and shows a fine specimen, with tubular funnel-shaped branches, differing greatly from Imperato's species.

Much confusion has been caused by the fact that, while *Schizoporella spongites* has been generally used as the name of one of the species included in the original diagnosis and description of Pallas, a large proportion of modern authors have followed him in placing *Porus anguinus*, a very different species, in their synonymic lists. Pallas' citation of Gualtieri makes it possible, however, to retain his name in the sense usually accepted; and Gaultieri's figure is thus to be regarded as the type of *Eschara spongites*.

It is unnecessary to discuss here the question how far the genus *Schizoporella* ought to be subdivided, but with this reservation I think the following synonymy may be accepted:—

SCHIZOPORELLA SPONGITES (Pallas). (Pl. I. fig. 2.)

Porus Anguinus crustaceus tubulatus capsulis minimis, Gualtieri, 1742, fig. after title of Pt. IV.
Eschara spongites (pars) Pallas, 1766, p. 45.
Schizoporella spongites auctt.

CALPENSIA NOBILIS (Esper). (Pl. I. fig. 1.)

Poro anguino, altrimente Adarce Imperato, 1599, p. 716, fig. on p. 723; 1672, p. 625, fig. on p. 632.
Lapis spongiæ Lochner von Hummelstein, 1716, Rariora Musei Besleriani, p. 87, Pl. xxviii (probably this species).
Adarce, ἀδάρκη, *Adarchi*, etc., Mercati, 1719, p. 112, text-fig. on p. 112.
Eschara spongites (pars) Pallas, 1766, pp. 45, 433.
Cellepora nobilis Esper, 1796, Pflanzenth., Fortsetz. I, p. 145, *Cellepora*, Pl. vii, figs. 1–3.
Eschara impressa Moll, 1803.

In the case of each of these common Mediterranean species a lengthy synonymy might have been given; and for *C. nobilis* reference should be made to Pergens (1887, p. 17). Canu and Bassler (1923, U.S. Nat. Mus., Bull. 125, p. 83) have, perhaps too confidently, dismissed most of Pergens' citations from the synonymy of this species.

Summarizing the above account, it may safely be maintained that the *Poro anguino* of Imperato is a common Mediterranean species, of considerable size and of striking appearance, and that it is frequently associated with *Posidonia*, when it assumes a massive, multilaminar condition. It is thus likely, *à priori*, to have been well known in classical times; and, if it had then acquired a reputation as a remedy, its use in medicine might have persisted through later centuries. It is probable, however, that *C. nobilis* was not distinguished in early days from other calcareous Polyzoa, and, indeed, several such species are to be found on *Posidonia*. But it may fairly be maintained that *C. nobilis* was one of the

organisms (and perhaps the principal one) known to ancient writers as *Adarce*, and to mediæval authorities as *Lapis spongiæ*.

III. John Ellis and the Linnæan Species of Polyzoa.

The consideration of the Linnæan species of Polyzoa must be preceded by a short account of the scientific work of John Ellis, who was born about 1710. Although he died in 1776, twelve years before the foundation of our Society, we have a special reason for being interested in him. Not only was he the intimate friend of Linnæus, and in many respects his valued counsellor, but our archives contain an extensive series of his correspondence with Linnæus and with other naturalists. The fact that we are the custodians of his manuscripts is in itself a sufficient reason for calling your attention to some of his activities. In compiling what follows I have depended, however, on the selection of the letters of Linnæus, Ellis, and others which was published by our first President, Sir James Edward Smith, in 1821. I have also to acknowledge the valuable assistance I have received from Mr. S. Savage, our present Clerk, who has made an invaluable annotated manuscript list of the original papers in our collection connected with Linnæus, Ellis, and their contemporaries.

It is not my purpose to give a complete account of Ellis's scientific work, which was carried out during the intervals he could spare from his occupation as a man engaged in practical business. I must pass over entirely the great services he rendered to Botany, in which he was an authority whom Linnæus consulted with deference. A list of 26 papers on Botany and Zoology, contributed by him to the 'Philosophical Transactions,' is given on pp. viii–x of the 'Natural History of Zoophytes,' by Ellis and Solander, which was published in 1786, after the death of both authors.

As far as Zoology is concerned, Ellis's most striking achievement was his remarkable work, usually referred to as the 'Essay on Corallines' (Ellis, 1755 *c*). In contrast with much of the literature of those days, Ellis's plates are of the highest order of merit, and the beauty and accuracy of most of the figures of Zoophytes, represented in their natural size or with slight magnification, are hardly surpassed in the most elaborate modern monographs. As a handbook of the common objects of our own sea-shore, particularly of Hydroids and of the more delicate branching Polyzoa, the Essay has no equal. The text contains descriptions of the species, which were adequately distinguished from one another, but the nomenclature was of course not binomial.

Ellis was not primarily concerned with classification, and he stated in his first chapter that his main groups were taken from Ray. He observed that "in disposing of the several Subjects, I shall rather have Regard to the similar Texture of the Substances, and the Figure of the Animals that inhabit them, than to-

the mere external Form and Appearance." He recognized, in fact, the important principle that affinities are to be decided by morphological characters. Taking into consideration the state of knowledge at the time, his grouping of the species shows considerable insight. His "Vesiculated Corallines" (p. 4) are a group of Hydrozoa, among which a few species belonging to other groups were included. Twenty-one of the species in this "Class" (including one, unnumbered, after No. 21) are Hydroids; four are delicate Ctenostomatous Polyzoa with the general appearance of Hydroids; and one is a colonial Vorticellid. This Class accounts for 26 of the species of *Sertularia* recognised by Linnæus in his Tenth Edition. The "Tubular Corallines" (p. 30), which come next, are also Hydrozoa, and the three species included were described by Linnæus (1758 and 1767) under *Tubularia*. The 12 "Celliferous Corallines" (p. 33) are without exception Polyzoa; and Linnæus showed less insight than Ellis had done by placing them all in *Sertularia*. The ten species of *Eschara* (p. 69) are also Polyzoa, with the exception of No. 5, *Millepora eschara* L., which was subsequently shown to be the egg-lamella of a Gasteropod Mollusc, *Natica*. The "Sponges" (p. 78) are represented by two species only, both familiar British forms of Porifera—*Spongia oculata* L. and *Spongia panicea* Pall.; and the five "Keratophyta" (p. 56) are all Alcyonaria. The term "Coral" was used by Ellis in a very general sense, as is shown by his group "Tubular Corals" (p. 90), which consists of two species of tubicolous Polychæta. The group "Alcyonium" (p. 82) includes "such marine Substances (chiefly the Nests and Matrices of Sea Animals) as are not reducible to any other Class." The first species, "Alcyonium pulmonis instar lobatum," is a Compound Ascidian, which has formed the subject of an elaborate recent paper, accompanied by a wealth of synonymy, by Hartmeyer (1914). The second is the familiar *Alcyonium digitatum* L. The next three were recognized by Ellis as the "ovaries or matrices" of Gasteropod Molluscs, including the "Sea washballs," some of the most familiar objects of the sea-shore, which he correctly referred to *Buccinum*. The sixth (No. 5), the "Sea-ragged Staff," is a Polyzoon, the well-known *Alcyonidium gelatinosum* (L.). The "Turky Feather" (*Fucus pavoninus* L., *Padina pavonia* of later authors) is a sea-weed, and it was supposed by Ellis to be possibly a vegetable. Although it appears in the text under *Alcyonium*, it is excluded from this group in the Contents. The Polyzoa are represented in the "Articulated Corallines" (p. 45) by two closely allied species, one of which is *Eschara fistulosa* L. (*Cellaria fistulosa* auctt.); and the remaining 11 species are Coralline Algæ.

The Tenth Edition of the 'Systema Naturæ' appeared in 1758, three years after the publication of Ellis's admirable treatise. So far as the Zoophytes were concerned, Linnæus had an easy task. It was not essential for him to make an independent study of these organisms, on which he was not indeed an

authority. He had merely to make use of the work of Ellis, particularly of the excellent Plates of the 'Essay,' and to give a binomial status to the species which had been clearly distinguished from one another by his predecessor. With few exceptions he adopted the species as they stood in the 'Essay.' The extent to which he employed this work may be illustrated by the Genus *Sertularia*, which in the Tenth Edition contains 44 species. No less than 41 of these, mainly Hydroids and Polyzoa, are based solely or principally on Ellis.

It is important to notice that, with few exceptions, the species considered distinct by Ellis are still valid, thanks to their acceptance by Linnæus. There are not, moreover, many cases in which Ellis can be shown to have included more than a single species in the same description. The Linnæan and other species based on the 'Essay' are thus unusually clearly defined, and they constitute an excellent starting-point for the binomial nomenclature of "Corallines." The innumerable difficulties which confront a student of the Polyzoa are rarely connected with the Linnæan species, a result which we owe entirely to Ellis.

The few species of Ellis which were not included by Linnæus in his Tenth Edition were mostly named later, either by Linnæus himself or by other authors. In a few cases several different names were proposed by authors working independently of one another, who based their new species on the same figure or figures in the 'Essay.'

The actual specimens used by Ellis do not seem to have been preserved. It is stated in the article "Ellis" in Rees' 'Cyclopædia' (1809, vol. xii) that four glazed frames containing specimens presented by Ellis to the Royal Society were later in the British Museum; but no trace can now be found of this collection. According to the same authority, the bulk of Mr. Ellis's Museum was sold by auction in London in June 1791.

I am obliged to Mr. Savage for calling my attention to the fact that a certain number of Zoophytes are in the Linnæan Herbarium, which is the property of our own Society. Thanks to this information, I have found representatives of the following Ellisian species, which were included, with one exception as noted below, in the Tenth Edition of the 'Systema Naturæ.'

HYDROZOA.

Sertularia abietina.
,, *antennina.*
,, *cupressina.*
,, *falcata.*
,, *geniculata.*
,, *halecina.*
,, *lichenastrum.*
Sertularia myriophyllum.
,, *pluma.*
,, *polyzonias.*
,, *pumila.*
,, *tamarisca.*
,, *volubilis.*

POLYZOA.

Sertularia anguina.	*Flustra truncata* (Ed. 12).
,, *ciliata.*	*Sertularia lendigera.*
,, *eburnea.*	,, *neritina.*
Eschara foliacea (*Flustra* auctt.).	,, *reptans.*

It would be natural to suppose that these are the type-specimens of the respective species, but there is some reason for coming to a different conclusion. A letter dated Jan. 1st, 1767, from Linnæus to Ellis, contains the following sentence:—"I thank you for the *Sertulariæ*, all the species of which I owe to you. These are your pledge of immortality, of which no revolution can deprive your name" (Smith, 1821, i, p. 196). It may be inferred that the specimens thus mentioned are the ones still to be found in the Linnæan Herbarium. They were received some twelve years after the publication of the 'Essay,' and there are no grounds for supposing that they were Ellis's original specimens, or even parts of them. It may be doubted, moreover, whether it occurred to Ellis to preserve the specimens from which his figures were drawn or on which his descriptions were based.

I conclude, therefore, that in every case where Linnæus introduced a new name, in 1758 or later, with a definite indication of a figure of Ellis, this figure is to be regarded as the type of his species. It will be noticed from the list given above that the collection in the Herbarium is by no means a complete set.

The 'Essay on Corallines' must thus be consulted by all systematists who desire to have a critical knowledge of the species there recorded. It is a fortunate circumstance that most of the descriptions and figures belong to common British species. It is an easy matter to obtain material by which one can convince oneself of the accuracy of the beautiful figures of Ellis.

IV. JOHN ELLIS AND THE ANIMAL NATURE OF ZOOPHYTES.

It may fairly be claimed for Ellis, as shown by the preceding Section, that he laid the foundation on which modern systematic work on Zoophytes has been based, and that he was notably a pioneer in the study of Hydroids and of the more delicate and flexible marine Polyzoa. This was by no means the whole, or even the most important part, of his services to Zoophytology. The 'Essay on Corallines' had the primary object of proving that Zoophytes were animals, and the evidence adduced in it is so convincing that, in spite of a certain amount of criticism by contemporaries who were not ready to accept his views, it finally brought the controversy on this subject to an end. His memoir was published at a fortunate time, and its immediate result was that the weight of Linnæus's high authority was thrown, although with some reservation, on his side. Earlier and conclusive

evidence was indeed in existence, but there can be no doubt that if it had not been for Ellis the treatment received by the Zoophytes in the 'Systema Naturæ' would have been very different.

A detailed account of the controversy concerning the nature of Zoophytes was given by Johnston (1838, pp. 3–29 and 1847, pp. 407–434); and the subject has also been well treated by A. S. Pennington (1885, 'British Zoophytes,' pp. 1–17) and by others. Although Johnston might be thought to have exhausted the subject by his admirable discussion, it is necessary to go over some of the ground again in order to be in a position to estimate Ellis's real share in the matter.

The credit for being the first to assert the animal nature of Zoophytes is often given to Imperato (1599), but the claim made on his behalf does not seem to me very strong. After stating (pp. 713, 622)* that the Red and certain other Corals are plants, and that some of the "Pori" (see p. 75) are of the same nature (pp. 715, 624), he concludes in his short summary (pp. 717, 626) that the Madrepores have degenerated into animals, and that the "Tubulara" (Organ-pipe Coral) is formed of animal concretions. In his special account of this organism (pp. 717, 625) he remarks that its animals are related to their tubes in the manner of bees to their honeycomb. He does not appear to have had any suspicion that other Zoophytes were animals.

The naturalist who first really established the animal nature of Zoophytes was Peyssonnel, but his elaborate memoir on the subject was coldly received, and has, indeed, never been published in full. The first reference to it is contained in an anonymous article which was published by the French Academy (Réaumur, 1729 *a*). Réaumur was here referred to as believing that the cortex of the (Red) Coral is a plant, and that the remainder is a "Pierre sans organisation." A certain observer, whose name was not mentioned, was said to have come to a different conclusion, namely, that many organisms hitherto regarded as marine plants are really of animal nature; but little information was given as to the details of these observations. In the same volume Réaumur (1729 *b*) published another article under his own name, giving a slight account of the observations previously criticized.

In his large work on Insects Réaumur (1742, vol. vi, Preface, pp. lxxiii, lxxiv) revealed the fact that Peyssonnel was the observer referred to in 1729, and stated that the esteem he felt for him had made him think it proper on the former occasion to suppress the name of the author of so bold a speculation. He explained that he had subsequently obtained evidence which had resulted in an entire reversal of his earlier judgment, and he expressed himself as an unqualified supporter of the views of Peyssonnel. He further made some apology for not having been convinced at once by the evidence detailed in Peyssonnel's memoir, which had been sent to him for publication.

* The references are to the 1599 and 1672 editions.

In 1741 and 1742 Bernard de Jussieu had studied Zoophytes on the coast of Normandy, and in a memoir dated 14th November, 1742 (published in a volume dated 1745), he produced the most convincing evidence, accompanied by excellent figures, that *Alcyonium digitatum*, *Flustra*, and other Zoophytes are animals. On p. 301 he expressed his conclusion that most of the marine productions then regarded by botanists as plants are probably animals, "confirming the system of M. Peyssonnel." This important paper, by de Jussieu, is apparently the first in which really satisfactory evidence on the subject was actually published. De Jussieu used the term "Polypes" for the living organisms of Zoophytes, described by various other authors as "insects."

On November 18th, 1742, a letter was read to the Royal Society (1744, Phil. Trans. xlii, p. 219 *n.*), containing the first indication of Trembley's well-known work on *Hydra*, thus preparing the way for the acceptance of the view that many marine Zoophytes were also animals.

Donati, in 1750, had also recognized that certain Zoophytes were at least partially of animal nature, although his conclusion that they occupy a position intermediate between plants and animals is no advance on the results of de Jussieu, of which he does not appear to have had any knowledge.

Detailed information with regard to Peyssonnel's results was given, for the first time, by Watson (1753, read May 7, 1752), who stated that M. Peyssonnel had sent his memoir, a manuscript of more than 400 pages, with a letter dated Guadalupe, May 1, 1751, to the Royal Society, for publication in the 'Philosophical Transactions.' Watson gave a sympathetic account of the paper, and stated that he had himself seen the polypes of a Coralline in Sussex; referring also to de Jussieu's observations. He concluded by observing that "the Royal Society is greatly obliged to M. de Peyssonnel, for his transmitting this manuscript, which I consider as a very valuable literary present." In spite of this favourable judgment the memoir remained unpublished, and the only satisfactory information available, at that date, as to its contents is contained in Watson's summary.

A later analysis of Peyssonnel's manuscript was published by Flourens in 1838. The original observations, proving that the "flowers" which had been described by Marsigli in the Red Coral are animals, were made in 1723 and 1725. Flourens quoted part of a letter written to Peyssonnel on June 2, 1726, by Réaumur, who expressed his disbelief in the conclusion that Coral and Lithophytes are the work of "insects." In 1726 Peyssonnel was given an appointment as physician and botanist in Guadeloupe, where his studies were continued. His manuscript is stated to have been written in 1744, and Flourens describes it as a treasured possession of the Paris Museum. I have ascertained that the Royal Society appears to have no record of the return to the author of the manuscript which was rejected in 1751, but it

may be presumed that this was done; and it is to be inferred from what is said by Flourens that the document at Paris is the actual manuscript which had been studied by Watson.

Flourens remarked that the style of Peyssonnel's composition was negligent and, indeed, almost barbarous, and that a considerable part of it, not concerned with the question of the nature of Zoophytes, would not be worth publishing. These defects may have had something to do with the rejection of the memoir by two leading scientific societies. But, subtracting these portions, there remained much which represented a fundamental advance of knowledge. Not only was complete proof supplied in the case of the Red Coral, but reasons were given for the conclusion that other marine organisms, such as Madrepores, Millepores, Lithophytes, Corallines, and Sponges, were also to be regarded as animals. Peyssonnel admitted that his proof as to the "Corallines" was not complete; but it is not clear whether this term referred to Zoophytes, to Coralline Algæ, or to both. His evidence as to the Sponges proved later to have been erroneous (see p. 89).

The earliest publication by Ellis on Corallines was his paper (1754 *a*) read to the Royal Society on March 17, 1753. He here gave good descriptions and figures of two species of "a remarkable Coralline" [*Bugula*, Polyzoa], and he alluded to Corallines as "beautiful sea-productions, hitherto claimed by the botanists," with more than an indication that he regarded them as animals. Another paper (1754 *b*), read Nov. 8, 1753, described a "Cluster-Polype" [*Umbellula*, Alcyonaria] as composed of polypes, and is incidentally of great interest as a record of an organism "which appears to be an animal, not a vegetable," which had been obtained at a depth of 236 fathoms. It should be remembered that the abyssal depths of the ocean were supposed, at a much later date, to be devoid of animal life. In his next paper (1755 *a*, read Feb. 7, 1754) he expressed the opinion that many Corallines as well as Corals are animals, and he gave good figures of the polypes of *Tubularia* and of the Herring-bone Coralline [*Sertularia halecina* L.]. A further contribution (1755 *b*, read June 13, 1754), containing the results of his observations during a visit to Brighthelmstone [Brighton] with Ehret, in 1754, is accompanied by figures of the polypes of several Hydroids. It is of interest to notice that in the "cells" of a Celliferous Coralline [*Scrupocellaria*, Polyzoa] he noticed "black spots," which he stated to be "the contracted bodies of dead polypes." This is apparently the first correct identification of the "brown bodies" so characteristic of Polyzoa.

The 'Essay on Corallines,' where the visit to Brighthelmstone is mentioned in the Introduction (p. viii), was published in 1755. Ellis stated, on p. vii, that "about June 1752" he had suspicions that several organisms "which had hitherto been considered by Naturalists as Marine Vegetables, were in Reality of animal Production," and he referred to his visit, in August 1752, to the Island of Sheppey, where he obtained proof that this view was correct.

It is clear from his published memoirs and from his correspondence with Linnæus (Smith, 1821) that Ellis claimed for himself the discovery of the animal nature of Zoophytes. It is equally clear, from the dates given in the above summary, that his results had been anticipated, to a considerable extent, by others. On p. xvi of the Introduction to the 'Essay' he referred, however, with appreciation to the work of Trembley, pointing out that the budding described by that author [in *Hydra*] elucidates the mode of growth of the marine polypes. I have been unable to find any reference in the 'Essay' to the opinions which had been expressed by Réaumur (1742), de Jussieu (1745), Donati (1750), or Peyssonnel (1753, from Watson's summary).

Ellis's discovery of the animal nature of Zoophytes was probably entirely original, in the sense that he was not indebted for inspiration to any earlier worker. In the Introduction to the 'Essay' he gave an explicit account of the circumstances which led to it. In the autumn of 1751 he received collections of "Sea-plants and Corallines" from Anglesey and Dublin. He preserved some of the specimens by laying them out on paper, according to a method he had learned from Prof. Büttner (see below, p. 92). He was at first interested in arranging them in "a kind of Landscape," and, on the suggestion of Stephen Hales, he submitted specimens of his work to Her Royal Highness the Princess Dowager of Wales. His scientific curiosity had, however, been aroused, and he determined "to separate all the different Species, and to dispose them in proper Classes," an investigation which involved the use of a microscope. He soon discovered that they differed from one another in texture, and that in many of them the texture was such as to indicate that they were of animal nature. In order to determine whether this suspicion was correct he visited Sheppey in August 1752, and his examination of living specimens fully convinced him "that these apparent Plants were ramified Animals." He appears not to have seen the memoirs of Réaumur and de Jussieu. The middle of the 18th century was a stormy period, and the state of war with France which began, after 1740, with the War of the Austrian Succession must have affected the interchange of scientific literature between England and France. The omission of reference to Peyssonnel is more difficult to understand. Ellis was a Fellow of the Royal Society, and it is extremely unlikely that he could have been unacquainted with Watson's abstract, published in vol. xlvii of the 'Philosophical Transactions,' particularly in view of the fact that two of his own papers were published in the succeeding vol. xlviii. There is evidence that, at a later date, he knew of Peyssonnel, whose conclusion with regard to sponges is mentioned in two letters written by him to Linnæus in 1765 (Smith, i, pp. 164, 172). On pp. 146, 147 of the posthumous 'Natural History of Zoophytes' (Ellis and Solander, 1786) Ellis referred to Imperato, Rumphius, Peyssonnel, and Donati as authors who had recognized the animal nature of certain Zoophytes; but his appreciation of Peyssonnel was by no means cordial.

I have found further evidence which is of interest in this connexion in the MS. Journal Book of the Royal Society, vol. xxii. Watson's account of Peyssonnel's researches was given to the meeting on May 7, 1752. At the next meeting (May 14) these researches were criticized by Dr. Stukeley, who maintained that Zoophytes are not animals. On May 28 Mr. Watson, who had not been present on May 14, corrected some of the statements of Dr. Stukeley, who read a second paper at the same meeting. On June 11 Dr. Stukeley further maintained that Corals are true vegetables. At the meeting of June 18, 1752, the Society received a paper on Zoophytes by Dr. James Parsons and a letter from Ellis himself, containing "an Explanation of four sheets forming part of Mr. Ellis's collection of Sea Plants .... he distinguishes which of them are in his opinion vegetables and which the work of animals."

There is evidence elsewhere that Ellis considered himself at liberty to ignore the results of others. Pallas had offended him by certain criticisms of the 'Essay on Corallines' in his 'Elenchus Zoophytorum' (1766); and in a letter, May 10, 1771, to Linnæus (Smith, i, p. 261) Ellis says "I am resolved not to mention Dr. Pallas in my book by name." The earlier part of the work in question (Ellis and Solander, 1786) thus consistently omits references to Pallas in places where they might have been expected; but this author is mentioned frequently, later in the volume, under the species of *Madrepora*; for which Solander was probably responsible.

Before leaving the subject of Ellis I must mention his accuracy as an observer and the good judgment he usually showed in difficult matters. His success in finding polypes in many Zoophytes naturally predisposed him to expect to find them elsewhere, but he exercised a commendable restraint in not letting his theoretical conceptions carry him beyond the evidence. He had repeatedly looked for polypes in Sponges, and he emphasized the fact that he had been unable to find them. His opinion that Sponges are animals was based partly on their chemical analysis (1755 *c*, p. 79). He here admitted his inability to discover "any other kind of Organization than that of a hollow Tube variously inflected," the tubes sending out side-branches in various directions which inosculate and unite to form a reticulation which extends through the inside of the whole mass. This is not a bad description, and in a letter to Linnæus, Dec. 21, 1762 (Smith, i, p. 161), Ellis stated that "Mr. Solander and I have seen the holes or sphincters in some of our sponges, taken out of the sea, open and shut while they were kept in sea-water; but discovered no animal like a Polype." In his letter written about August 1765 to Linnæus (Smith, i, p. 172) he criticized and rejected Peyssonnel's conclusion (1759) that sponges were formed by small "worms," which that observer had found in their cavities. Peyssonnel's description seems to me to show that these "worms," which were 2–3 lines long and $\frac{1}{3}$ of a line thick, were Dipterous larvæ (maggots). It is not stated that they were seen in living

material, and they may possibly have been found in dead sponges which had been left exposed to the warmth of a tropical sun.

In one respect Ellis was mistaken in his judgment, and this was in connexion with the Calcareous Algæ. Linnæus placed them in the genus *Corallina*, most of his species having been based on the descriptions and figures of the 'Essay on Corallines.' These organisms gave Ellis much trouble, as is shown by many passages in his correspondence with Linnæus (Smith, i, pp. 147, 188, 197, 200, 203, 208). Although he did not persuade himself that he had seen polypes in *Corallina*, he supposed that they might possess something analogous to polypes, too small to be visible with his magnifying-glasses, or that they might be constructed like sponges, "contrived in such a manner as to suck in and throw out the water" (Ellis and Solander, 1786, p. 109). He was specially influenced by the dogma of Linnæus, "that all calcareous substances are most truly of animal production" (*ibid.* p. 108), and its corollary "that Corallines, consisting of that substance, do belong to the animal kingdom." By a curious irony of fate, the President of the Royal Society, in presenting the well-deserved Copley Medal to Ellis, selected, as the most noteworthy contributions to science of that author, two papers read before the Royal Society in 1767 (Phil. Trans. lvii, pp. 404, 428); one on the animal nature of *Corallina* and the other on a Zoanthid described by him as *Actinia sociata*. In the first of these papers Ellis had maintained a thesis which was definitely wrong, and the second was not comparable in importance with the earlier work on Zoophytes. Ellis himself considered the fact that a Sea Anemone might assume a colonial form an important one in helping to bridge the gap between Actinians and the Hydroids and Polyzoa described by him in the 'Essay.'

The correspondence between Ellis and Linnæus is of great interest, and the letters were those of close personal friends, each of whom had the highest opinion of the other's scientific merits. Linnæus constantly referred difficult matters to Ellis, and treated his opinions with the greatest respect. Thus, in a letter, Nov. 8, 1769 (Smith, 1821, i, p. 240), he says, "Your discoveries may be said to vie with those of Columbus. He found out America, or a new India in the west: you have laid open hitherto unknown Indies in the depths of the ocean."

It was characteristic of Ellis that his opinions were formed from his own observations and experiments, and it is not too much to say that he was nearly always right in his main conclusions. He submitted his specimens to Linnæus as the great authority on systematic Zoology and Botany, but his profound admiration for him did not prevent him from expressing his opinion frankly when he thought that Linnæus was wrong. In several cases his scientific acumen proved to be greater than that of his distinguished correspondent, as is shown by the part of the correspondence which deals with the nature of Zoophytes and of Fungi. In a letter to Ellis, Sept. 16, 1761 (Smith, i, pp. 151, 152), some six years after the

publication of the 'Essay,' Linnæus stated that Zoophytes are "vegetables, with flowers like small animals, which you have most beautifully delineated. . . . As Zoophytes are, many of them, covered with a stony coat, the Creator has been pleased that they should receive nourishment by their naked flowers. He has therefore furnished each with a pore, which we call a mouth." After remarking that they have a nervous system and stating that they "may even be truly called vegetables, as having flowers, producing capsules, etc.," he continues: "Yet as they are endowed with sensation, and voluntary motion, they must be called, as they are, animals; for animals differ from plants merely in having a sentient nervous system, with voluntary motion." It is not easy to understand from these passages what Linnæus really thought, and the difficulty is not removed by turning to the letter, Dec. 8, 1767 (Smith, i, p. 220) to Ellis, in which Linnæus says "Previous to the year 1740, I, like all the rest of the world, considered Corals and Zoophytes as plants. But from that period, when the smaller tribes of animals came to be rightly understood, I have never done so."

Whatever Linnæus's real opinion was at that time, he was so far influenced by Ellis's results as to make an unprofitable attempt to prove that Fungi were animals. A letter, Jan. 1, 1767 (Smith, i, p. 194), which he wrote to Ellis contains details of a method for showing that the spores of various Fungi become "little worms" when kept in water for several days. Ellis might well have accepted with enthusiasm this extension of his own results, but he showed his true worth by refusing to do so without submitting the matter to an independent examination. On Sept. 8, 1767 (Smith, i, p. 213), he wrote to Linnæus to inform him of the conclusions he drew from his own experiments. These "plainly shewed to me, that these seeds, though put into water according to your directions, have no animal nature of their own, and are only moved about by the *animalcula infusoria*." Linnæus did not readily accept the correction, and in his letter, Oct. 1767 (Smith, i, p. 214), he stated that the "animalcula infusoria" are the living seeds of Mould, *Mucor*, and that the commonness of these organisms in water is thus explained. Ellis replied, Oct. 30, 1767 (Smith, i, p. 216), that animalcula were to be found in almost all standing, or even river water, and that they grow and increase in numbers as soon as they meet with their proper *pabulum*. Linnæus's suggestion was further negatived by the fact that the same animalcula appear in infusions of other vegetables besides Fungi. In a later letter, Nov. 1, 1768 (Smith, i, p. 237), he made the important statement that the animalcula were prevented from appearing, though kept from June to September, by putting an infusion in a closely-corked phial of water, but that they soon appeared if the cork were replaced by paper tied close down.

One further matter remains to be mentioned, but I should not have thought it necessary to allude to it if it had not been given a prominent place in the German edition (Ellis, 1767) of the 'Essay on Corallines.' As this edition is presumably to be found

in many libraries, and is probably used in the absence of the original edition, it seems desirable to refer to the statement in the German edition (p. 5) that the honour of discovering the real nature of Zoophytes is to be given to Ellis and Büttner jointly. Ellis, who had thanked Büttner, on p. v of the Introduction to the 'Essay on Corallines,' for having shown him a method for mounting Zoophytes on paper and for many useful hints in Botany, referred to the claim on behalf of Büttner in a letter to Linnæus written about August 1765 (Smith, i, p. 170). He there stated that in a printed book of the lives of the Professors at Göttingen Büttner had claimed for himself the discovery of "the manner of generation of many habitations of Polypes, taken for plants," and had further said "These discoveries he laid, 1750, at London, after a voyage thither, before the Society of Sciences there; when John Ellis from Ireland, a member of it, communicated them afterwards to the world, under the title of an Essay towards Corallines, with copper-plates, which he got done at his own expence [*sic*], besides some additions of his own." Ellis's answer to this astounding statement, contained in the same letter to Linnæus, is an explicit denial of the whole assertion; a disclaimer which was fully accepted by Linnæus in letters dated Sept. 24 and Dec. 27, 1765 (Smith, i, pp. 177, 182). In another letter to Linnæus, Oct. 29, 1765 (Smith, i, p. 179), Ellis stated that he had obtained certificates from the Secretaries of the Royal Society that Büttner had submitted no papers of any sort to that Society. Johnston's comment (1847, p. 419 *n.*) is that "a more barefaced literary theft has not been recorded." It may be added that the editor of the German edition of the 'Essay' (pp. 5, 6) made a special appeal to Büttner to publish "the rich treasure of his discoveries," and that the failure to respond to this invitation may be taken as an admission that the claim could not be substantiated.

V. Protrusion of the Polypide.

The method by which the tentacles are brought into action is a matter of fundamental importance in the Polyzoa, since to a large extent it has dominated the structural arrangements and, accordingly, the evolution of the individual units of the colony. In the Entoprocta, one of the two main subdivisions, the tentacles lie in an external recess, protected by a thin duplicature of the body-wall, the opening of which can be closed over them by a sphincter-muscle. When this is relaxed the tentacles are merely spread out like the petals of an opening flower, and this method does not involve the more complicated mechanism which is necessary in the majority of the Polyzoa.

The second subdivision, Ectoprocta, includes the vast majority of the Polyzoa, and in all these the tentacles are not merely opened and closed, but are retracted into an introvert—the

tentacle-sheath—which lies in the body-cavity. At each protrusion of the tentacles a considerable portion of the contents of the body-cavity passes from the inside of the space bounded by the body-wall to the outside. The body-cavity is a closed space, and the amount of fluid it contains could not alter appreciably, during the rapid action of retraction at least, even if it were possible for fluid to diffuse into it during the slower movement of protrusion. Two methods of meeting the difficulty are theoretically possible, and both have actually been adopted, in different groups of the Ectoprocta. In the first method the body-wall contracts during protrusion, so that the volume of its contents has considerably decreased by the time the tentacles have been fully expanded. This can only happen in species in which the body-wall is flexible, either in all its parts or in a limited region which can be depressed during protrusion to an extent sufficient to balance the reduction of the volume of its original contents. In the second method the body-wall is rigid, and the requisite compensation for the periodical removal of the tentacles is provided by the existence of a sac which opens to the exterior and lies inside the body-cavity. During the protrusion of the tentacles the necessary amount of water enters the sac and it is ejected when the tentacles are retracted.

The act of retraction is a comparatively simple process, and it is performed in essentially the same manner in all groups of the Ectoprocta. It takes place with considerable rapidity, mainly by the contraction of the strong retractor muscles, which run longitudinally through the zoœcium, originating from the body-wall at some distance from the orifice, and being inserted into the polypide in the neighbourhood of the lophophore, the base from which the tentacles arise.

The relations of the muscles which cause the protrusion of the polypide are not identical throughout the Ectoprocta, the differences depending on the arrangement of the flexible part of the body-wall. In the Phylactolaemata most of the body-wall is muscular, and both longitudinal and circular fibres are present. The fibres are separated from one another by intervals, so that the two layers together have the appearance of a network. The uncalcified body-wall is flexible, and the contraction of its muscles produces sufficient pressure on the cœlomic fluid, while diminishing the volume of the space it surrounds, to force out the tentacles.

In the Gymnolæmata the body-wall has a simpler character. The muscles which cause protrusion were described by Farre (1837, p. 397) in *Bowerbankia* and other genera with a flexible body-wall as the "parietal muscles," and they consist of fibres, in two longitudinal series, which are arranged transversely across the more or less cylindrical zoœcium, the wall of which is delicate and uncalcified. Farre realized that the pressure produced on the cœlomic fluid by the contraction of these muscles was at least partially responsible for the act of protrusion, but their mode

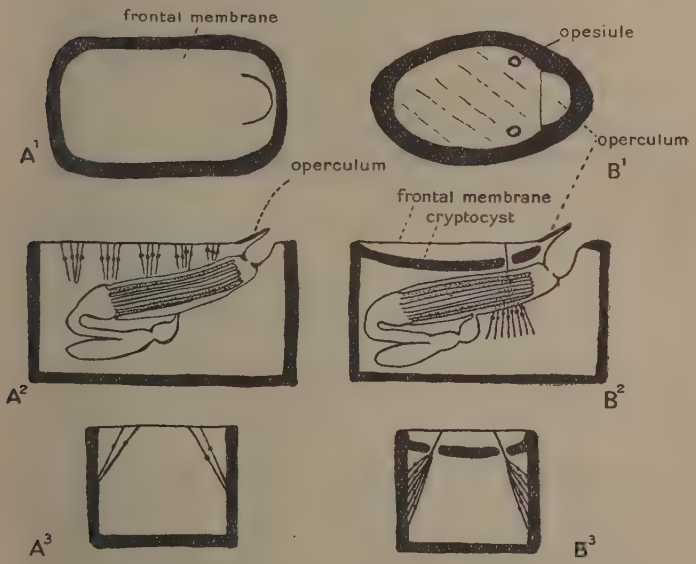
of action was more correctly described by Allman (1843) in *Paludicella*. Throughout the Gymnolæmata protrusion of the tentacles is probably effected by parietal muscles, which in their most highly evolved form depart widely from what appears to have been their original condition. The body-wall of the Polyzoa has not the mobile character which it possesses in a worm, but it seems reasonable to regard the isolated fibres, or groups of fibres, which constitute the parietal muscles as the last remains of an originally continuous layer of circular muscles.

In the encrusting habit of growth, as found in a few Ctenostomata and in many Cheilostomata, each zoœcium may be described as a box, attached by its basal surface to its substratum and by its four sides to its neighbours. Five of its six surfaces are thus practically immovable. The sixth or frontal surface is the only part of the body-wall which can be altered in form by the contraction of the parietal muscles. Instead of lying in the body-wall, which was probably their primitive condition, they run obliquely across the body-cavity, in small groups consisting of a few muscle-cells, and in two longitudinal series, as in *Bowerbankia*. They originate from the immovable lateral walls and are inserted into the flexible frontal wall, which is depressed by their contraction. In the Anasca, probably the most primitive group of the Cheilostomata, the frontal surface remains in its original position, and its uncalcified and flexible portion, with which the parietal muscles are connected, is known as the "frontal membrane." This membrane may constitute the whole of the exposed frontal surface (text-fig. 2, A^1–A^3), but it is frequently reduced in size by the calcification of the peripheral part of the frontal wall proximally and laterally. In other cases (text-fig. 2, B^1–B^3) there may be an internal, calcareous, second wall, presumably evolved to give additional protection to the organs covered by the frontal membrane. This wall, the "cryptocyst" (see p. 112), is developed slightly on the basal side of the frontal membrane as an ingrowth into the body-cavity from the proximal and lateral calcareous walls (B^2, B^3); and it may extend so far distally that it reaches the base of the operculum. A substantial modification of the parietal muscles is necessitated by this new development. Instead of having a number of pairs of separate and comparatively weak muscles, running along the whole length of the zoœcium on either side, the parietal muscles are reduced to a single pair of stronger muscles, each of which passes into a tendon inserted into the frontal membrane. These muscles are known as the "depressor muscles," from their function of depressing the frontal membrane. Their tendons are sometimes inserted into two linear longitudinal thickenings or sclerites of the membrane, thus distributing the effect of their contraction over a larger region than if their insertions had remained simple points. In Anasca in which this arrangement occurs, a dead zoœcium which has lost its frontal membrane appears to have its frontal surface almost entirely calcified,

except the "orifice," the part of it which is closed by the chitinous operculum. The calcification cannot, however, be quite complete, since the tendons must in some way reach the frontal membrane. They may pass through a pair of small notches of the distal end of the cryptocyst, on either side of the base of the operculum, or these emarginations may close, so as to give rise to two "opesiules" traversed by the depressor tendons (text-fig. 2 B^1–B^3).

The Ascophora constitute the second large group of the Cheilostomata, with a different arrangement of the parietal

Fig. 2.

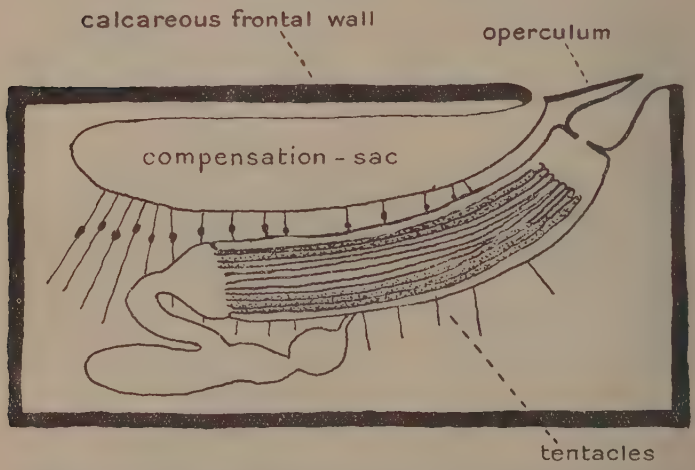


Protrusion of the polypide in Anasca. A^1–A^3, *Membranipora*; B^1–B^3, *Micropora*. A^1, B^1, frontal view of zooecia; A^2, B^2, longitudinal sections; A^3, B^3, transverse sections. In B the tendons of the single pair of parietal muscles (depressor muscles) pass through two pores ("opesiules") in the calcified cryptocyst.

muscles. The frontal wall is entirely calcified, except for the orifice. The zooecium appears at first sight to have completely rigid walls, and the details of the mechanism of protrusion remained unknown until Jullien (1888 *a*, *b*), in two short papers, gave a brief but correct account of a structure which he described as the "chambre à eau de compensation." He realized clearly that the flow of water into and out of this organ is the essential

factor which permits protrusion and retraction to take place in a rigid box. Busk had seen part of the same organ four years earlier than Jullien, and had come tentatively to the same conclusion. His actual words are "it is not improbable that this division of the zoœcial cavity into two compartments by a flexible membranous diaphragm will be found pretty generally in all zoœcia of which the wall is wholly rigid, and that it is intended for the purpose of allowing the compression of the perigastric cavity necessary to effect the protrusion of the polypide, which would otherwise seem to be scarcely possible in a perfectly unyielding box" (Busk, 1884, p. 168). He gave no explanation of the manner in which this result is produced. Waters (1888, pp. 3, 10, 17, 18) had mentioned the same organ in the same year

Fig. 3.



Protrusion of the polypide in Ascophora; longitudinal section of a zoœcium. The compensation-sac opens to the exterior at the base of the operculum.

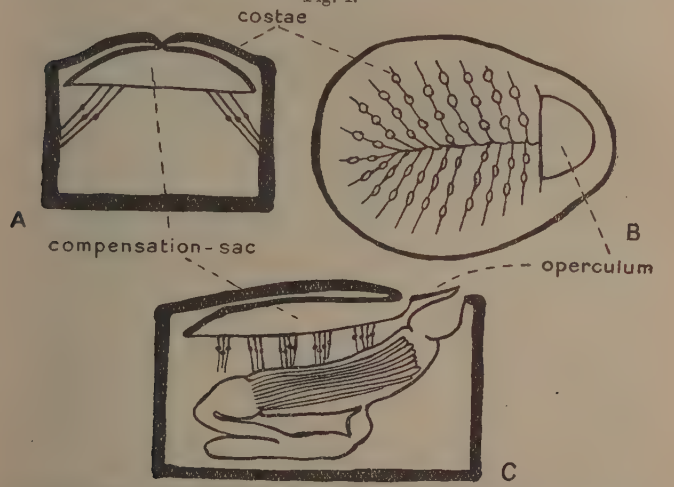
as Jullien, but he did not understand its nature. None of these authors had elucidated the muscular arrangements by which protrusion is effected.

A very important fact in the anatomy of the Polyzoa had, however, been discovered, but for some years it was entirely ignored, or in a few cases was mentioned only to be contradicted. Some years later (1901) I accidentally found an arrangement which reminded me of Jullien's previously discredited account; and, on further investigation, I ascertained that, as Busk had suggested, it was of general occurrence in a large group of the Cheilostomata.

Jullien's compensation-sac (text-fig. 3) is a spacious cavity, with excessively thin walls, which underlies the rigid frontal wall. It usually opens, as Jullien had correctly stated, at the proximal border of the operculum, or sometimes more proximally by an aperture which had long been known as the "median pore." In the former group of cases, which are much the most numerous, the base of the operculum passes into the floor of the sac, and is thus not continuous with the frontal wall of the zoœcium, as had been assumed to be the case until Jullien described the real relations.

The morphology of the compensation-sac receives a partial explanation by the consideration of the Cribrilinidæ (text-fig. 4),

Fig. 4.



Protrusion of the polypide in Cribrilinidæ. The uncalcified frontal membrane is overarched by a roof formed of costæ, which have fused with one another except at the pores or lacunæ seen in B.

in which certain modified marginal spines—the "costæ"—overarch the frontal membrane, and finally unite with one another to form a secondary calcareous wall, leaving slits or a row of pores ("lacunae") between adjacent spines. The cavity between the secondary wall and the frontal membrane has the precise relations of Jullien's chamber, and is, in fact, a compensation-sac. Its floor is formed by the original frontal membrane, which is freely exposed in the young zoœcium; and a double series of parietal muscles are inserted into it, exactly as in the Anasca, in which no calcified protection for the frontal wall has been evolved. Protrusion of the polypide is brought about in the same way as in the Anasca, by the contraction of these muscles.

The "Cribrimorph" Polyzoa—a term introduced by Lang for the Cribrilinidæ and their allies—were numerous during the Cretaceous Period, and their antiquity is a reason for supposing that they may have been ancestral to some at least of the Ascophora. The extent to which evolutionary processess were taking place at this time may be estimated by reference to Lang's account of the Cretaceous Cribrimorph Polyzoa given in vols. iii and iv (1921, 1922) of the British Museum 'Catalogue of the Fossil Bryozoa (Polyzoa).'

The Cribrilinidæ are not intermediate, however, in all respects between the Anasca and the Ascophora. In the latter assemblage the calcareous frontal wall does not actually develop as a series of costæ. Its pores are perforations in the calcareous wall,

Fig. 5.

Three zoœcia of *Figularia fissa* (Cribrilinidæ); *a* has five pairs of costæ, each two separated by a single lacuna. The costal area is much reduced in *b* and *c*, with, respectively, five and three lacunæ.

containing living cells in contact with the body-cavity, and not opening into the compensation-sac; and this structure is an invagination, on the proximal side of the operculum, which grows beneath the calcified frontal wall. I have recently (1926, p. 472) called attention to a condition found in *Figularia* (text-fig. 5), one of the Cribriline genera, which may prove to be important in this connexion. The zoœcia of *F. fissa* vary to a considerable extent, even in a single colony, in the size of their costal area. This may be almost as extensive as in most other Cribrilinidæ, but in some of the zoœcia it is much reduced and consists of only a very few short costæ, which occur just proximally to the operculum. The remainder of the frontal surface is probably

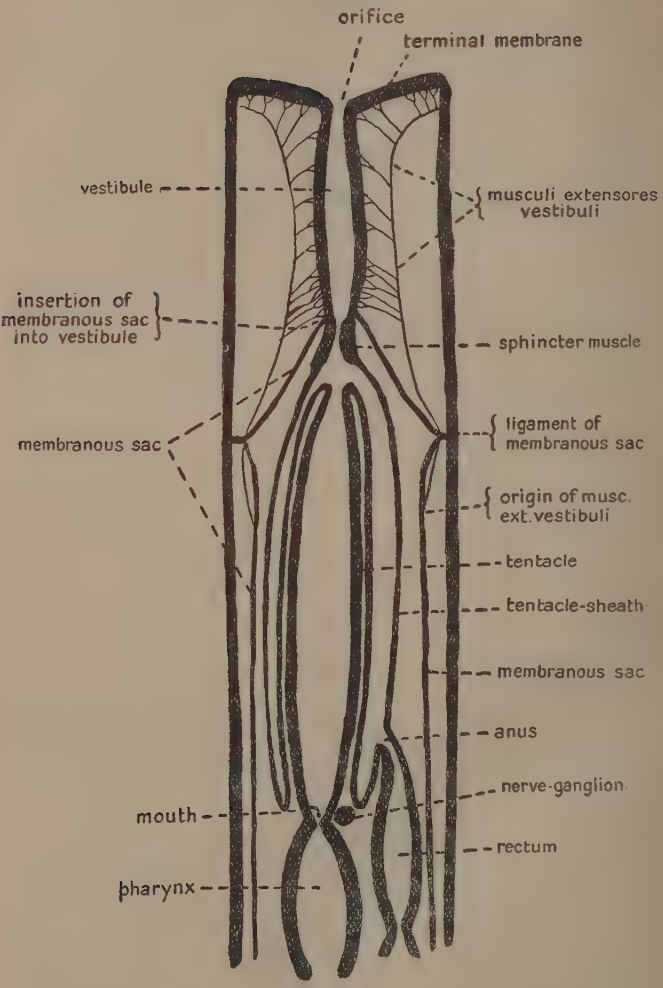
a calcified part of the original frontal wall, and it has not been formed by the fusion of costæ. I have accordingly suggested that some at least of the Lepralioid genera are derived from Cribrimorph ancestors in which the costal area has been successively reduced. If nothing else had happened the frontal membrane would have become too small to be acted on by the parietal muscles to an extent sufficient to force out the polypide. My suggestion was accordingly this: that, concurrently with the reduction of the costæ, the frontal membrane became invaginated into a sac extending proximally beyond the costal area, beneath the greater part of the original frontal wall.

The morphology of the frontal wall of the Ascophora requires further investigation, and it is possible that evolution may have proceeded in at least two ways: (1) by the conversion of costæ into the calcified frontal wall, the frontal membrane remaining as the floor of the compensation-sac; (2) by the reduction of the costal area, with the other changes indicated above. It may be added that various Cribrimorph forms, both recent and fossil, show a reduction of the costal area comparable with the condition sometimes found in *Figularia fissa*.

The above-described results with regard to the morphology of the Cheilostomata had provided no explanation of the mode of protrusion in the Cyclostomata. In an encrusting Cheilostome the frontal surface of the zoœcium is relatively large, and its flexible frontal membrane, in a primitive or modified form, is of sufficient size to be utilized, by the agency of the parietal muscles, for the protrusion of the polypide. The zoœcium of the Cyclostomata is always well calcified, and is typically a long and narrow cylindrical tube the mouth of which is closed by a circular uncalcified "terminal membrane." This membrane, which is to be regarded as homologous with the frontal membrane of the Cheilostomata, is relatively small, and in its unmodified form it could hardly have been utilized for the protrusion of the polypide. The details of this process were completely unknown in Cyclostomata until they were described by Borg (1923, 1926 *a*), who has recently published the results of his admirable studies, which constitute a notable advance in our knowledge of the morphology of this group.

The middle region of the circular terminal membrane is invaginated to form a vestibule (text-fig. 6, p. 100), which is never everted. At its proximal end it passes into the tentacle-sheath, an atrial sphincter muscle being sometimes present at the junction of the two parts. The whole of the polypide is included in a thin-walled sac, of obscure morphological significance, which appears to be peculiar to the Cyclostomata. The distal end of this structure—the "membranous sac" of Borg—is attached by a narrow annular insertion to the proximal end of the vestibule. It rapidly enlarges, so that more proximally it almost equals the body-cavity in diameter. The commencement of the fully enlarged portion is attached by eight short ligaments to the

Fig. 6.



Protrusion of the polypide in Cyclostomata; longitudinal section of the distal end of a zoœcium. After Borg.

body-wall. The sac then passes, without materially altering its diameter, nearly to the proximal end of the zoœcium, becoming attached to the body-wall where the two retractor muscles originate, and also near the proximal end of the zoœcium. The sac is completely closed, and it contains not only the polypide, including the tentacle-sheath with its tentacles, but also the gonad and the two retractor-muscles. It thus divides the body-cavity into two distinct chambers, an "exosaccal" part surrounding and containing the much larger "endosaccal" part.

The exosaccal cavity, at its distal end, contains the "musculi extensores vestibuli" (about seven or eight in number in *Crisidia cornuta*), which Borg regards as a modification of the parietal muscles of other Polyzoa. They run longitudinally from their origin, which is on the outer surface of the membranous sac, slightly on the proximal side of the eight ligaments, and they end at the outer border of the terminal membrane. They give off a number of fibres, which are inserted into the terminal membrane and the wall of the vestibule.

The outer body-wall is too extensively calcified to permit satisfactory observations to be made on the *modus operandi* in the living condition; and Borg's explanation is accordingly based on the structural arrangements. He suggests that the contraction of the *musculi extensores vestibuli* dilates the vestibule, into which water must enter from the outside, and draws down the terminal membrane, the eight ligaments holding the membranous sac in position during this process. The cœlomic fluid of the relatively large distal part of the exosaccal cavity is forced towards the proximal end of the zoœcium, thus exerting a pressure on the membranous sac and forcing out the tentacles. The atrial sphincter has already dilated in order to allow these changes to occur. Protrusion takes place slowly, and when it is completed the mouth of the polypide is about level with the orifice of the zoœcium. Retraction, by the two retractor muscles, is a much more rapid event, as is usual in Polyzoa. Borg's explanation seems to be satisfactory, but it does not account fully for the membranous sac. The method of protrusion assumed by him would apparently be equally efficient if the membranous sac did not exist.

VI. Cyclostomata: other Points of Interest.

This section deals largely with Borg's important new work on the morphology of the Cyclostomata, but some of the results of his investigations have already been dealt with, as being appropriate to the preceeding section.

(a) *Nanozooids.*—It has long been known that in certain Cyclostome genera small zoœcia occur among the ordinary zoœcia; but the anatomy of these individuals had not previously

been described. In *Diplosolen obelia* they are about as numerous as the normal zoœcia, but they are approximately one-third of their length and are much narrower, a short distal portion, with the orifice, being of specially small diameter. Most of the parts of a normal zoœcium are present in these "nanozoids," including the terminal membrane, vestibule, tentacle-sheath, retractor muscles, membranous sac, and *musculi extensores vestibuli*. The alimentary canal is represented by a vestige; the tentacle-sheath contains only one tentacle, which is not ciliated; and no reproductive organs are to be found. The tentacle can probably be protruded, and the reduced polypide can degenerate to form a brown body, a new polypide of the same kind being then regenerated in its place. Borg comes to no definite conclusion as to their function; but it is perhaps legitimate to suggest that in view of the presence of a specially well-developed epidermis (Borg, 1926 *a*, pl. ii, fig. 11) the tentacle may perhaps secrete a substance of a defensive nature.

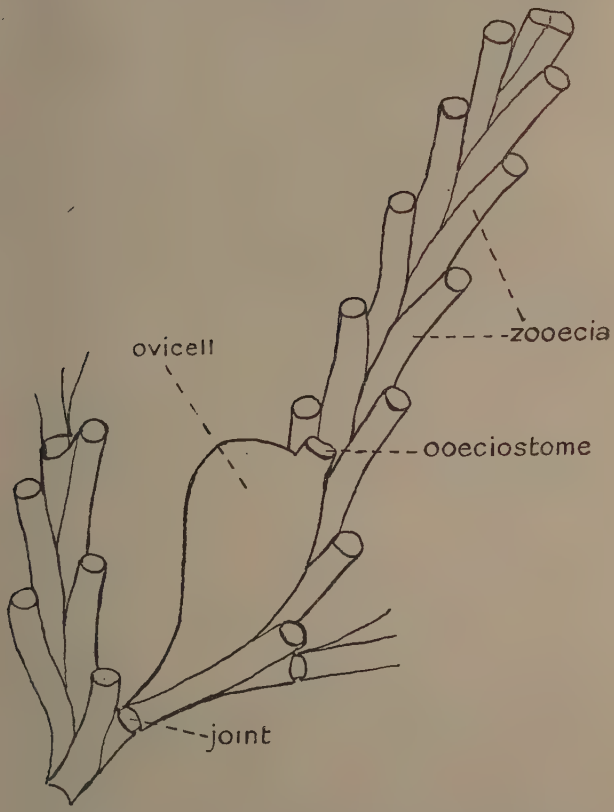
(b) *Nutrition*.—The food consists principally of Diatoms. A current is produced by the lateral cilia of the tentacles, between which it passes outwards. This results in the formation of a current, directed straight down the tentacular funnel to the mouth. The muscular pharynx acts as a suction-pump which receives the food. If distasteful particles are added to the water the tips of the tentacles may be approximated and the axial current is no longer formed. The action of the cilia is now to drive away the distasteful particles through the slits between the tentacles. Borg adds the interesting observation that in *Electra pilosa* (a Cheilostome) the eggs when laid by a polypide are often sucked in by the tentacular funnel of a neighbouring polypide, being then ejected and caught by another polypide; and so on, until they reach the edge of the colony and become free. This is one of the rare instances of the development of the egg in the external water, not in a brood-cavity.

(c) *Embryonic fission*.—It was my good fortune, in 1890, to discover the fact that embryonic fission of a very pronounced type occurs in Cyclostomata. As the result of the investigation of *Crisia*, *Lichenopora*, and *Tubulipora* (Harmer, 1890–1898), genera which are representative of three very different families, the generalization was made that development probably takes place in this remarkable manner throughout the Cyclostomata. This conclusion has been confirmed by Calvet (1900, p. 334), Miss Robertson (1903), and in much greater detail by Borg, who states (1926 *a*, p. 408) that embryonic fission in the Cyclostomata is a firmly established fact. Borg has made a most careful and elaborate investigation of this subject, not only in the genera mentioned above, but also in *Diastopora* and *Hornera*. The species in which embryonic fission is now known to occur are so fully representative of the recent Cyclostomata, with the exception of *Heteropora* (which has not yet been investigated), that there is good reason for the assumption that the ovum in this order never

develops in the conventional way, but always gives rise to a multitude of larvæ. It is a curious fact that the closest parallel to this process in other animals is to be found in certain parasitic Hymenopterous insects (Marchal, 1904).

Borg has added materially to our knowledge of this subject,

Fig. 7.



Part of a colony of *Crisia eburnea* (Cyclostomata), showing zoœcia and an ovicell.

correcting certain points of detail in my original accounts and adding observations of new facts. He is doubtless right in stating that the structure which I described as the tentacle-sheath of the ovicell is really the membranous sac, an organ which I had failed to discover in the zoœcia and ovicells.

Embryonic development in the Cyclostomata takes place in ovicells which are not homologous with those of Cheilostomata. In the latter group the ovicell is a brood-chamber in which the embryo develops, and it rarely contains more than a single embryo. Waters (1909, J. Linn. Soc., Zool. xxxi. p. 142) stated that two or more larvæ occur in the ovicell of *Thalamoporella*, one of the Cheilostomata. The egg in this order is produced in a normal zoœcium and its mode of entry into the ovicell was long unknown. The observations of Gerwerzhagen (1913) on *Bugula* show that it is laid through a pore on the anal side of the lophophore, and that it passes into the ovicell during a protruded condition of the polypide, the tentacles of which are reflected during the process. The incubatory cavity may be regarded as a space between the distal wall of the fertile zoœcium and the frontal wall of its distal successor (Harmer, 1926, p. 203), and it is thus morphologically an external brood-space.

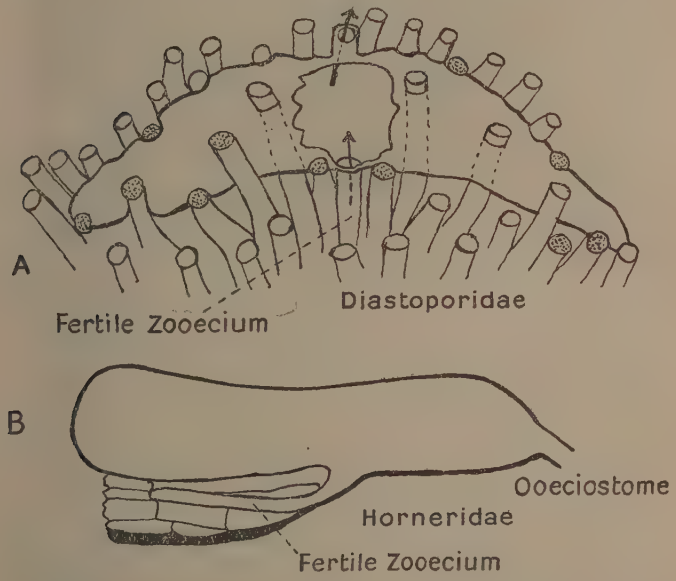
The ovicell of the Cyclostomata (text-fig. 7, p. 103) is usually a modified zoœcium, which in the early stages of its growth is indistinguishable from its ordinary neighbours. The resemblance at this time is not merely in external form, but the fertile zoœcium agrees with the others in its general anatomy. A polypide appears in the commencing ovicell, and may assume full functional activity, including the faculty of taking food. In *Crisiella producta*, as shown by Borg (1926 *a*, p. 416) the tentacles of the fertile polypide do not reach their full length, and the alimentary canal does not differentiate all its parts; but in some other Crisiidæ the fertile polypide is developed in a complete form. In cases where the ovicell fails to reach maturity in this family, degeneration of the polypide may take place, followed by the appearance of a new functional polypide; and the imperfect ovicell may remain in the colony as an individual intermediate in external form between a zoœcium and an ovicell. In *Lichenopora* there may be two successive functional polypides in the young stage of an ovicell which is destined to reach maturity.

The fully-developed ovicell of a Cyclostome is typically a zoœcium dilated in its middle region, but remaining without much modification of form in its proximal and distal portions. There are thus three regions (text-fig. 8), as follows:—(1) the proximal part, which corresponds in position and proportions with the greater part of a zoœcium; it contains the egg, and is at first inhabited by at least one polypide; (2) the much larger, often greatly dilated, middle part, which contains the developing embryos and the larvæ which are ready to escape; (3) the distal "oœciostome," a short tube, sometimes reduced to a mere pore, through which the larvæ escape, this part representing the region of the orifice of a zoœcium. In the Crisiidæ the transition from the first to the second region is gradual (text-fig. 7), and the ovicell is typically pear-shaped. In other families the dilatation of the middle region generally commences abruptly, and this part is often greatly expanded and lobed. The lobes may grow round

some of the zoœcia, on the distal side of which their cavities may fuse, so that the zoœcia remain as free columns passing vertically through the cavity of the ovicell (text-figure 8, A). In *Lichenopora* the proximal and distal regions have the usual form, but the inflated middle region has special features (as described below), which are correlated with the exceptional character of the zoarium in its family.

The germ-cells of the Cyclostomata originate precociously, and in this respect they are remarkably similar to those of certain

Fig. 8.



Ovicells of Cyclostomata. A, frontal view, part of the roof having been removed, to show the communication of the dilated middle region of the ovicell with its narrow proximal portion (the original fertile zoœcium) and with the narrow distal region opening to the exterior, the oœciostome (upper arrow). B, longitudinal section, showing the three regions of the ovicell, the proximal section (marked fertile zoœcium) being in series with the ordinary zoœcia. After Borg.

Tunicata which also increase by budding. The distal region of a branch or lobe which is still growing and giving rise to new zoœcia consists of what Borg terms the "common bud" ("samknopp" of Smitt). This is a region which is constantly cutting off new zoœcia by the formation of calcareous septa (see p. 112), leaving at each such division a fraction which can continue the process. The common bud is closed distally by a terminal membrane, composed

of an external cuticle with underlying ectoderm and mesoderm. The growth of the common bud takes place mainly round its periphery, where new cells originate by cell-division and calcareous matter is laid down. This marginal region is the "growing-zone," and it is the only part where polypide-buds begin to develop and where germ-cells of either sex originate.

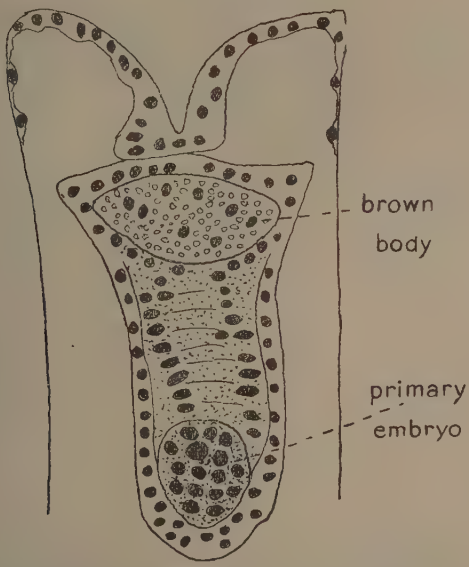
The germ-cells are produced in large numbers, gradually differentiating from the growing zone. They make their first appearance simultaneously with the polypide-buds, at a stage when the tissues of the terminal membrane are still in an embryonic or hardly differentiated condition; and they are distinguished from the unmodified mesoderm-cells by their larger size at a time when the polypide-bud has made little progress beyond its incipient condition. The germ-cells are at first of unrecognizable sex. Some of them, which have become connected with the proximal end of a young polypide-bud, give rise by repeated divisions to a mass of tissue which becomes a testis. The male cells usually mature in zoœcia which do not contain eggs, but in *Lichenopora* three different conditions may occur in the same colony:—(1) certain zoœcia are entirely male, and they are indistinguishable from zoœcia which have no gonads; (2) the young ovicell may be entirely female; or (3) it may possess both male and female cells, which are present at the same time. The fertilization of the egg has not been observed in Cyclostomata, and it is perhaps significant that the testes in this order are conspicuously large, filling a considerable proportion of the zoœcial cavity and producing innumerable spermatozoa. This fact suggests that a zoœcium is not self-fertile even in *Lichenopora*, where the two kinds of sex-cells may occur simultaneously in the same zoœcium (or young ovicell), since the production of spermatozoa would seem to be excessive if fertilization could be so easily effected.

Those germ-cells which do not come into relation with a polypide-bud are destined to degenerate. A small proportion of the female cells succeed, however, in attaching themselves to a polypide which belongs to a young ovicell, not yet recognizable as such from its external appearance. In most cases the ovicells develop late in the life of the colony, and are therefore found only in its more distally situated branches or lobes. In species of *Lichenopora*, which differs in so many respects from other Cyclostomes, the ovicell may commence to differentiate at almost the beginning of colonial life, even as a modification of the second or third zoœcium (text-fig. 11, A, on p. 114). Borg has shown that in various genera most of the polypide-buds are provided with germ-cells during the breeding-season, but it does not follow that all which have eggs will give rise to ovicells. In the great majority of cases the egg loses its connexion with the polypide-bud, and later degenerates, the bud becoming a normal polypide of an ordinary zoœcium. An egg-cell which is destined to undergo further development becomes surrounded by a cellular follicle (text-fig. 10, A, p. 109), which is not formed in the majority which degenerate. As many as six eggs, each with a separate follicle or sometimes

enclosed in a common follicle, were found attached to a fertile polypide in *Berenicea patina*. Usually one alone of these develops further, less often two.

The fertile polypide does not long survive after the egg has acquired its follicle, but part of it degenerates into a brown body, usually when the egg has divided into two or three blastomeres. The bud had previously given rise to the full complement of structures which are found in the ordinary zoœcia. The part which degenerates consists of the alimentary canal with the tentacles, the tentacle-sheath, the nerve-ganglion, and the

Fig. 9.



Lichenopora verrucaria (Cyclostomata). Longitudinal section of young ovicell, the embryo corresponding in age with that shown in fig. 10, C. The follicle has a characteristic elongated shape, with a definite relation to the brown body, which has been formed by the degeneration of the polypide.

retractor muscles. The membranous sac, its ligaments, and the *musculi extensores vestibuli* do not degenerate, and the vestibule also remains unaffected. The egg-follicle next gives rise to nutritive tissue, a larger amount of which is provided somewhat later by the membranous sac. How necessary this is for the successful accomplishment of the functions of the ovicell may be inferred from the fact that the minute ovum is destined to give rise to 100 or more larvæ, each many times larger than itself.

In *Tubulipora* and *Lichenopora* (text-fig. 9) the brown body takes up a definite position with regard to the membranous sac

and nutritive tissue, and it is a conspicuous compact mass which can be recognized until a late stage in the growth of the ovicell. The constancy of this association seems to indicate that the brown body is playing some part in the physiological processes involved. Although no experimental evidence on the subject can be quoted, I venture to suggest that the fertile brown body is comparable, physiologically, with the corpora lutea of the Mammalian ovary. The corpus luteum, "through the secretion it produces, acts as a stimulus to the growth of the uterine mucosa and the maintenance of the increased uterine nutrition which are necessary for the occurrence of gestation" (Marshall, 1925, p. 102). In the Crisiidæ, however, the brown body becomes divided into fragments at an early stage, and after a time ceases to be distinguishable. If there were any truth in the above suggestion it would be necessary to assume that the fragments could perform the function of the compact brown body in the other genera.

While these processes have been taking place, the egg has divided, in a very irregular manner, into a few blastomeres, which appear to be completely separated from one another (text-fig. 10, B). Similar irregularities have been recorded in the segmentation of the ovum in other animals in which embryonic fission occurs (Harmer, 1893, p. 228); and the coincidence may be more than accidental. The primary embryo later becomes a solid rounded mass of cells, which are not at first obviously differentiated into distinct layers (text-fig. 10, C).

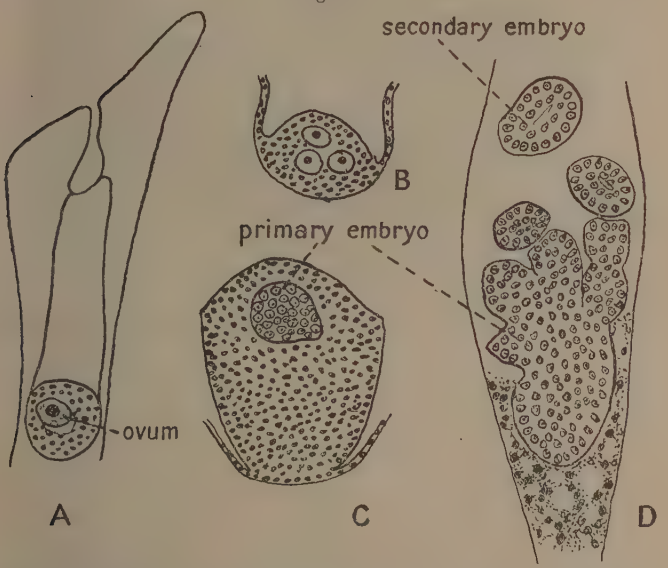
The membranous sac of a moderately young ovicell of *Crisia* is a thin-walled vesicle, the embryo lying at its proximal end, surrounded by the remains of its follicle (text-fig. 10, A). The primary embryo becomes larger and regularly ovoid, with some indication of an outer epithelial layer surrounding a solid inner mass of cells. The membranous sac is, later, nearly filled with nutritive tissue, and the embryo then increases in size, soon putting forth several thick finger-like projections at its distal end. These become constricted at intervals, and the portions thus indicated are successively separated as ovoid "secondary embryos," which pass into the nutritive tissue. Their structure resembles that of the primary embryo—an outer layer surrounding a solid mass in which a cavity soon appears. The inner layer does not develop into an alimentary canal, a structure which is wanting in the Cyclostome larva.

The secondary embryos increase greatly in size, and acquire the characters which occur constantly in this group before birth. Before they become free they collect in a special compartment of the membranous sac, from which they ultimately escape to the exterior through the œciostome. The process of birth is perhaps assisted by the *musculi extensores vestibuli*, which with the membranous sac persist throughout. The vestibule has become merged in the terminal membrane before the escape of the ciliated larvæ, and the distal end of the membranous sac has thus been brought into close relation with the œciostome.

In some cases at least the secondary embryos are not all formed directly from the primary embryo. This may give off masses of embryonic cells which subsequently divide into the definitive embryos. The number of secondary embryos commonly exceeds 100, all of which have usually been produced from one original ovum, though it seems probable that two ova sometimes develop in the same ovicell.

The Cyclostomata are thus characterized by concentrating their efforts on a very few ova. Although large numbers of eggs are

Fig. 10.



Embryonic fission in Cyclostomata (*Crisia*). A, young ovicell, after the degeneration of its polypide; the single ovum is contained in a cellular follicle. B, segmented egg, consisting of three blastomeres, apparently discrete, enclosed by the follicle. C, the primary embryo is now a compact mass of cells, the follicle having increased in size. D, the primary embryo is producing secondary embryos, which lie in the vacuolated tissue, presumably nutritive, derived from the follicle.

produced in their budding-zones, an extremely small proportion succeed in developing. When this happens a single minute egg gives rise to a number of relatively large larvæ. As the ovicell contains no polypide except in its initial stages, it is necessary to assume that the colony as a whole is providing the material at the expense of which the nutritive tissue and the secondary embryos are formed. There is no difficulty in this assumption, since the

tissues of adjacent zoœcia are continuous with one another through the pores in the interzoœcial calcareous walls. In correlation with the strain thus imposed on the zoœcia by the presence of even a single ovicell the ovicells are produced in small numbers. A colony of *Lichenopora* may possess only one enormous ovicell, and the remaining zoœcia, which are present in large numbers, are engaged in the general nutrition of the colony, including that of the ovicell, although many of them are also concerned with the nutrition of large gonads of the male sex.

(d) *Classification.*—As the result of his careful morphological studies Borg has proposed certain modifications of the classification of Cyclostomata which deserve attention. I cannot follow him in his conclusion, which he shares with certain other modern authorities, that the Entoprocta are so widely separated from the Ectoprocta that they can be left out of account in considering the Polyzoa (1926 *a*, p. 185); nor do I agree with the view (p. 490) that the Ectoprocta are nearly related to the Phoronidea. I do not here discuss these questions, but I may express my conviction that in their embryological development, in the mode of attachment of the larva, and in the method of budding the Ectoprocta show clear affinities to the Entoprocta. Additional evidence in support of this view is to be derived from the form of the alimentary canal and from the position of the ciliated tentacles and of the nerve-ganglion.

The classification of the Ectoprocta proposed by Borg (1926 *a*, pp. 490, 474–475) is as follows:—

Order 1. PHYLACTOLÆMATA.

Order 2. STENOLÆMATA, nov.

Division 1. Camptostega, nov.

Fam. Crisiidæ.

„ 2. Acamptostega, nov.

Fam. Tubuliporidæ, Diastoporidæ, Entalophoridæ, Corymboporidæ, Frondiporidæ, Fascigeridæ.

„ 3. Pachystega, nov.

Fam. Horneridæ.

„ 4. Calyptrostega, nov.

Fam. Lichenoporidæ.

Order 3. GYMNOLÆMATA.

Suborder 1. Cryptostomata.

„ 2. Cheilostomata.

„ 3. Ctenostomata.

The Order Stenolæmata is proposed for the Cyclostomata, with the possible addition of the fossil Trepostomata (p. 490), which precede them in geological sequence. The diagnosis of the Stenolæmata is based on the Cyclostomata, as there is naturally no evidence that the Trepostomata possessed a membranous sac or developed by embryonic fission.

The new groups are not happily named, since, in his desire for uniformity of terminology, Borg has neglected the significance of the patterns he adopts. Phylactolæmata and Gymnolæmata, as introduced by Allman (1856, p. 10), referred to the presence or absence of an epistome guarding the gullet or entrance to the alimentary canal. Stenolæmata of Borg is presumably an allusion to the narrowness of the zoœcia, and would be misleading if translated literally. The termination-stega was appropriate as introduced by Levinsen (1902, p. 2) for groups of the Cheilostomata, since it referred, with its prefixed component, to some character of the frontal wall, the roof of the zoœcium; but it has no special significance in connexion with the first two of Borg's divisions of the Cyclostomata. The Camptostega are the erect Cyclostomata (Crisiidæ), in which the zoœcium is flexible owing to the presence of chitinous joints, which occur at intervals even between the primary disc and the base of the main stem; and the name has no reference to the character of the frontal wall or of its homologue the terminal membrane. The Acamptostega are similarly Cyclostomes which are not flexible (without joints); and here, too, the termination is unsuitable. Pachystega and Calyptrostega can, however, be defended, since the former term refers to the thickness of the calcified walls of the zoœcia, and the latter to the veil constituted by the terminal membrane, which covers the whole of the frontal wall of the zoarium.

In certain details, some of which have been discussed by previous authors, the Phylactolæmata resemble the Cyclostomata; and Borg concludes (1926 *a*, p. 486) that the cylindrical form of the zoœcia in these groups is a primitive feature. They "possibly show a somewhat closer resemblance to one another than either of these groups does to the Cheilo-Ctenostomata" (p. 490).

The divisions of the Cyclostomata correspond in general with those usually adopted; but Borg has new observations of morphological importance, particularly with regard to the Horneridæ and the Lichenoporidæ. In drawing up his arrangement he has taken into consideration, wherever possible, the early stages of colony-formation, the constitution of the body-wall, and the method of budding.

In the initial stages of the colony the "primary disc" (text-fig. 11, on p. 114), formed by the calcification of the body-wall of the metamorphosed larva after its fixation, grows into a cylindrical tube, which may be straight or curved. The mouth of the tube is closed by an uncalcified terminal membrane. The distal end of the tube is the "common bud;" and from it and its derivatives are formed all the future units of the colony. A new

zoœcium or ovicell becomes indicated by the development of an oblique calcareous septum, which grows into the body-cavity from the future basal wall of the colony. The septum is situated near the distal end of the tube and also near one of its sides, and, as seen edgeways in a frontal or basal view, it is parallel with the opposite wall of the tube. The septum in most families grows so as to meet the terminal membrane, which is thus divided into two parts, the larger of which is connected with the original tube and will form, with some further prolongation, the first zoœcium of the colony. The smaller part remains as a common bud, which may be described as a funnel, the basal and frontal surfaces of which have been considerably flattened. In a longitudinal section cut in a frontal plane the common bud is triangular, and it is successively divided, as it grows, by septa which originate from its basal surface and are alternately parallel to the two sides of the triangle. The common bud, in fact, in its mode of division resembles the apical cell of the growing point of certain plants. On each occasion when a septum is formed the larger part of the terminal membrane remains as the terminal membrane of a zoœcium and the smaller part as that of a common bud, except when the growth of the branch is completed by the employment of the entire terminal membrane in the construction of the last zoœcium.

The above description refers specially to the Crisiidæ, in which the zoœcia alternate regularly on the two sides of the branch. The form of the colony in other families depends on the manner in which the zoœcia are cut off by the developing septa. Thus, in the Tubuliporidæ the zoarium commonly grows out as a fan-shaped structure, often adnate to its substratum and variously lobed. This form is produced by frequent bifurcations of the septa, by which means the number of zoœcia in a transverse row is increased. The basal side of the distal end of the lobe consists of an actively growing common bud, which is subdivided by numerous developing septa. In the Entalophoridæ the divisions take place in such a way that the erect zoarium consists of cylindrical branches, in which the common bud occupies the axial part and is surrounded on all sides by zoœcia.

Before considering Borg's classification further, it is necessary to explain his use of certain terms. "Cryptocyst" (see p. 94) is a term which was introduced by Jullien (1882, p. 274), and was defined by him as "un diaphragme qui divise la zoœcie en deux chambres, l'une supérieure ou externe, l'autre inférieure ou interne." "Gymnocyst" was a complementary term proposed by Levinsen (1909, pp. v, 8), and was defined on p. v as a "calcified part . . . which arises by the transformation of a covering membrane." Both terms have been used mainly in connexion with the frontal wall (Cheilostomata), which was described by Jullien as double in those species which possess a cryptocyst. These definitions by themselves do not give a very clear idea of what is meant, and some further explanation is required. The frontal wall of the Anasca (Cheilostomata) is often composed entirely of

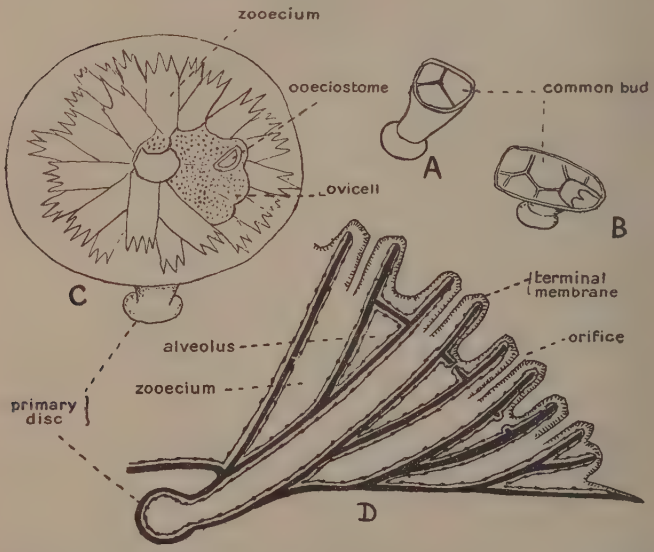
the frontal membrane. The peripheral region may become calcified, however, especially at the proximal end of the zoœcium, and to a less extent laterally ; and this calcified part is Levinsen's gymnocyst. In other words, the gymnocyst is a calcified part (not always present) of the frontal body-wall. As used by Borg (1926 *a*, pp. 190 *u.*, 198) the gymnocyst is any part, frontal, basal, or lateral, of the exposed body-wall, whether calcified or not. In this sense the term gymnocyst includes both the frontal membrane of a Cheilostome and the terminal membrane of a Cyclostome ; and in these parts it is an uncalcified membrane composed of an external cuticle, with underlying ectoderm and mesoderm. If the gymnocyst is calcified the calcareous matter is deposited by the ectoderm immediately beneath the cuticle. A calcareous wall with ectoderm and mesoderm on both sides is a cryptocyst. The interzoœcial septa are thus constituted, and, as no cuticle enters into their composition (Borg, p. 192), they fall within this definition. In Cheilostomata the cryptocyst is most often found on the frontal side (see p. 94); but in the Horneridæ among the Cyclostomata it is also extensively developed on the basal surface of the branches as well as frontally. In Cheilostomata with a double frontal wall (see p. 94) the space between the gymnocyst and the cryptocyst is the "hypostegia" of Jullien. Borg (p. 198) uses the term "hypostegal cœlomic cavity" for any part of the body-cavity situated between layers of gymnocyst and cryptocyst.

In Borg's divisions Camptostega and Acamptostega the external body-wall is constituted entirely by the gymnocyst. The calcified zoœcial outer walls have no living tissue outside them, and the only increase in thickness of which they are capable is a limited addition of calcareous matter formed by the ectoderm on their inner sides.

The third and fourth divisions are differently constituted, with the result that a considerable amount of secondary external calcification takes place. The Calyptrostega (Lichenoporidæ), in particular, have a mode of growth (text-fig. 11, p. 114) which is strikingly different from that of all other recent Cyclostomata. Their initial stages (A, B) resemble those of the other divisions, but the tube formed as an outgrowth of the primary disc becomes a wide funnel, very short in the longitudinal direction. The septa which grow from its basal wall advance towards the terminal membrane, which they never quite meet (D). They are formed in such a way that the zoœcia are developed on the central side of the common bud, which persists round the entire circuit of the mouth of the funnel. Part of the wall of the funnel grows over the primary disc (C), and the colony becomes discoidal or plano-convex, being attached by its original outer wall (the "basal lamina") to the substratum (D). The basal lamina is a gymnocyst, and no secondary calcification can be formed on this surface. A continuous terminal membrane covers the entire free surface of the colony, being reflected over the projecting edges of the zoœcia

into their vestibules without losing its continuity. As the distal ends of the zoœcia diverge from one another, spaces ("alveoli") occur between them, but do not extend to the basal lamina. The cavities of the alveoli have been derived from the body-cavity of the common bud, and they thus constitute a zoarial cœlomic cavity, which is roofed by a part of the common terminal membrane of the frontal surface. The alveoli differ from the zoœcia by never developing polypides.

Fig. 11.



Lichenopora (D, after Borg). A, young colony, consisting of the primary disc and three immature zoœcia, the second or third of which commonly becomes the ovicell in *L. verrucaria*. B, older colony, in frontal view, the common bud having completed the formation of the first zoœcium. C, young colony, the margin of which has not yet overgrown the primary disc; the formation of the middle, dilated region of the ovicell is already well advanced. D, longitudinal section of a colony, showing the relations of the terminal membrane.

Owing to this peculiar behaviour of the terminal membrane the whole of the free surface of the colony in Lichenoporidæ is covered by a veil of living tissue, under the protection of which extensive secondary calcification is produced by the underlying cryptocyst—often to such an extent as to obscure the arrangement of the zoœcia. Horizontal partitions of cryptocyst grow from the outer walls of the zoœcia into the cavities of the alveoli, which thus acquire calcareous roofs. The cavities which remain on the free side of the first completed alveoli may be similarly

subdivided, thus constituting a second tier of alveoli with calcareous walls. While in other divisions of the Cyclostomata the ovicell is formed entirely by the enlargement of a fertile zoœcium, in the Lichenoporidæ some of the alveoli are added to this structure, a process involving the absorption of parts of their separating calcareous walls.

The Pachystega (Horneridæ) resemble the Lichenoporidæ in the fact that the interzoœcial septa formed in the budding regions never meet the terminal membrane, which is accordingly not divided into a number of separate circular portions corresponding with the zoœcia. The earliest septa of the colony appear to grow into the common bud in such a way that the zoœcial orifices are surrounded on all sides by the original terminal membrane, with which they are continuous. The initial stages have not actually been observed, but Borg concludes that this is what takes place from the study of sections of the base of an older colony. The zoarium is accordingly covered on all its surfaces by living tissue (gymnocyst), and secondary calcification takes place to a specially large extent from the underlying cryptocyst, as in the Lichenoporidæ. The general architecture of the colony is very different, however, in the two families, the colony of the Horneridæ being erect, ramose, and almost coral-like. Secondary calcification is not restricted to the frontal surface, as in Lichenoporidæ, but it occurs basally and laterally as well as frontally. The ovicell of *Hornera* (text-figure 8 B, p. 105) is a zoœcium enlarged in its middle region, as in all families except the Lichenoporidæ, and it does not increase in size by the addition of alveoli.

The terminal membrane of the Horneridæ is thus continuous over the entire colony, and a certain amount of calcification may take place in it by the deposition of calcareous matter beneath its cuticle. The cryptocyst-structures may be obscured by this calcification of the gymnocyst.

The secondary calcification of the cryptocyst is particularly extensive in the Horneridæ, the process beginning near the tips of the branches, at the expense of the ectoderm covering the cryptocyst. The longitudinal ridges which grow into the hypostegal cœlomic cavity are at first longitudinal, but they become connected by transverse ridges, so that the surface assumes the reticulate character found in various species of *Hornera*.

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EXPLANATION OF PLATE I.

Fig. 1. *Colpensia nobilis* Esper. From Imperato, 1672, 'Historia Naturale,' fig. on p. 682. "Poro anguino, altrimente Adarce."

Fig. 2. *Schizoporella spongites* Pallas. From Gualtieri, 1742, 'Index Testarum Conchyliorum,' fig. after Title of Pt. iv. "Porus Anguinus crustaceus tubulatus capsulis miniatis."

The Hooker Lecture. [Read 14th March, 1929.]

THE ORIGIN OF ADAPTATIONS.

By E. J. Allen, D.Sc., F.R.S., F.L.S.,

Director of the Marine Biological Association of the United Kingdom.

It is laid down that the lecture, which you have honoured me by asking me to deliver to-day, shall be upon some subject specially associated with the name of Sir Joseph Hooker. In the summer of the year 1858 Sir Joseph Hooker, in association with Sir Charles Lyell, persuaded his friend Charles Darwin to allow them to communicate to the Linnean Society the joint paper by himself and Alfred Russel Wallace, which has become historic, "On the Tendency of Species to form Varieties; and on the Perpetuation of Varieties and Species by Natural Means of Selection." The paper was read to the Society on the evening of July 1st, 1858.

Throughout the long years of preparation which led up to this event, a landmark in the history of Biology, and, indeed, in the history of human thought, Hooker and Darwin were on terms of closest intimacy, and the wonderful series of letters which passed between them shows how much Darwin relied on the opinions and scientific knowledge of his younger friend. Their consultations and discussions continued steadily throughout the later years of Darwin's life.

It is the wish of your Council that I should try to put before you some idea of the present position of the theories of organic evolution which have arisen from the paper read to the Society in 1858. On an intimate occasion like the present, perhaps you will forgive me if I give somewhat undue prominence to the views of British naturalists, who are our friends and colleagues.

The title I have selected for what I have to say is "The Origin of Adaptations," because that, it appears to me, goes nearest to the heart of the problem of organic evolution. By an adaptation we mean nothing more than a character of an organism which has enabled a species to survive itself as such, or to survive until it is transformed into another species. It is survival that gives the measure of the value of the adaptation. But we must not forget that survival can only occur if the whole organism is adapted to the environment in which it lives to an extent that suffices.

Much emphasis in recent years has been laid on the consideration of the organism as a whole. I would ask you to go a step further, and to think of organism and environment as a unity. The idea of adaptation is a recognition of the fact that organism and environment are interlocked, are fitted closely to form that harmony which is nature and life. Organic evolution is a phase—the crowning phase may be—of cosmic evolution.

The Environment.

On the environment itself I have not time to dwell at any length, but one or two features may be emphasized. The term must be understood in no limited sense, but must include not only all those physical features and activities which have a determining influence on life, but all other living things whose existence in any way affects survival. The biological environment determines survival no less than the physical, and adaptation to both must be sufficient *.

It is fundamental to realise that the environment is not and never has been a fixed and constant factor. It must be thought of as in a condition of perpetual flux and change. Though many such changes are periodic, the exact conditions at any one moment are never repeated again. This is even more true of the biological environment than of the physical. The fauna as a whole of any area, whether in the sea or on land, when watched from year to year over long periods, shows fluctuations of extraordinary magnitude. Species once common may practically disappear, and years later may reappear abundantly with devastating effect on other organisms. The greatest of such changes are independent of human activities, though man, himself a part of the environment of other creatures, is undoubtedly responsible for much.

A second consideration which I wish to emphasize takes us back to the early days of marine natural history, and the buoyant spirit of Edward Forbes, whose joy in the study of sea animals in their natural habitat is still an inspiration.

> "The creatures strange the sea that range,
> Though mighty in their stations,
> To the dredge must yield the briny field
> Of their loves and depredations."

In his book 'The Natural History of the European Seas' (1859), published some five years after his death, Forbes develops the idea of "specific centres"—the "centres of creation" of earlier naturalists,—which we should now call "centres of distribution"; areas in which the representatives of the species are very numerous and tend to reach the largest sizes. Two orders of such centres of distribution can be recognized, centres of geographical distribution, and centres of more narrow local distribution, which in the sea are governed by the varied conditions on particular grounds.

In a paper published in 1899 †, in which an attempt was made to correlate the distribution of the fauna on the grounds near the Eddystone Lighthouse with the nature of the soil on the bottom, in and on which the animals lived, I was able to illustrate the importance of this principle of distribution. Each species must be regarded as being specially adapted to the conditions prevailing

* The French use "le milieu" to express "environment," which is perhaps better, since portions of both physical and biological environment may be ound enclosed within an organism.

† Allen, E. J., Journ, Mar. Biol. Assoc. v, p. 365 (1899).

at its own centre of distribution, for it is at that centre that the characters of the species are kept true. Species adapted to such a centre may radiate in gradually diminishing numbers to adjacent grounds, to which they are not really adapted, and upon which they would never flourish or succeed if the supply from the neighbouring centre were cut off. It is of importance, therefore, to remember that the environment we need to study in connection with the adaptations of a species is the environment at its centre of distribution.

The general physical conditions under which organisms live have been well discussed in a noteworthy book by L. J. Henderson, 'The Fitness of the Environment' (1913). Starting with a study of the living organism as a physico-chemical mechanism, Henderson first emphasizes the fact that it possesses a high degree of complexity, both structurally and functionally. Secondly, the living organism is durable, and such a complex mechanism can be durable only if both the internal and the external conditions in which it exists are stable and in constant equilibrium. Hence automatic regulations both of the environment and of the conditions within the organism are essential to life. There must be at least a rough regulation of temperature, pressure, and chemical constitution of environment and organism, and other regulations are also called for. Finally, a living being must be active; its metabolism must be fed with matter and energy; there must be constant exchange of matter and energy with the environment.

"Complexity, regulation, and food are essential to life as we know it, and in truth we cannot otherwise conceive of life." I make use very largely of the author's own words in putting his views before you. He then sets out to show that the environment on our own planet possesses a very special fitness to fulfil the demands of life. After tracing the history of the earth, he discusses the question of its atmosphere. As the temperature falls in the cooling of a planet the changes in the spectrum point to the presence of carbon; and hydrogen and oxygen are also there. As the cooling proceeds carbonic acid and water must normally result. In the earth's atmosphere carbonic acid has been very largely converted into oxygen and vegetable matter, which latter has been turned into enormous quantities of coal, peat, and other similar substances. It has been suggested by Koene that all the oxygen of the atmosphere has been formed from carbon dioxide in this way.

It is in the physical and chemical attributes of water and carbonic acid, and their constituent elements—carbon, oxygen, and hydrogen—that we find very many of the conditions which make life possible upon the earth. Taking these substances as the most essential part of the environment in which life goes on, Henderson shows how they are not only fit for life, but, from their special and peculiar properties, are the fittest of all substances known. The high specific heat of water—higher than that of nearly every liquid except liquid ammonia—gives it almost unique qualifications,

which are largely responsible for making the earth habitable. It is due to this, more than to any other property of water, that oceans, lakes, and streams maintain a nearly constant temperature, and this also effects a moderation of both summer and winter temperatures on the earth. The high heat-capacity of water is involved in the formation and duration of ocean currents, and increases the mobility of the environment of marine organisms. Indirectly this high specific heat of water influences the formation of winds in the atmosphere, and the resulting distribution of aqueous vapour. It helps also to regulate the temperature of living organisms themselves.

Similarly, the latent heats of melting and evaporation of water are both very high—the highest of any known substance—and these two properties operate powerfully both to equalize and moderate the temperature of the earth, and to regulate the body temperature of organisms. The quite anomalous expansion of water, when cooled at temperatures near the freezing-point, with the maximum density at 4° C., together with the more usual phenomenon of expansion on solidification, is largely responsible for many bodies of water in cold climates remaining in the liquid state.

There is nothing to compare with water as a solvent, and water being chemically inert, the dissolved substances undergo little chemical change. Thus, an extraordinary number of different substances become available for the organism to build up its complex structure. This is illustrated by the wealth of elements that can be recognized in sea-water, or in the blood and body fluids of land animals.

Ionisation takes place to a much greater extent in water than in any other fluid, a fact which tends to increase chemical activity between the substances in the solution, as well as the electrical phenomena in it. Then, again, of all common liquids, except mercury, water has the greatest surface tension, and this is of exceptional importance in the phenomenon of adsorption, which "influences and complicates almost every process of chemical physiology, for no product of life is without its colloids, *i. e.*, substances which are finely divided, and therefore endowed with great surface areas."

The properties of carbon dioxide, and of the compounds containing carbon, hydrogen, and oxygen, when looked at in a similar way, show equally unique features. The vast series of complex compounds based on the carbon atom would be unattainable with any other element.

Henderson lays special stress on the unique properties of the ocean as a medium for living things, and summarises the whole argument thus:—

"The physical and chemical properties which have been taken into consideration include nearly all those which are known to be of biological importance. There are no other compounds which share more than a small part of the qualities of fitness of water

and carbonic acid; no other elements which share those of carbon, hydrogen, and oxygen.

"None of the characteristics of these substances is known to be unfit, or seriously inferior to the same characteristic in any other substance. Therefore the fitness of the environment is both real and unique.

"The fitness of the environment is one part of a reciprocal relationship of which the fitness of the organism is the other."

Darwin's Theory.

Here we will leave the special consideration of the environment and pass to a closer consideration of the fitness of the organism. As we have already said, the condition which the organism must fulfil, if survival is to result, is that it shall continue always sufficiently adapted to its ever-changing surroundings. How does this adaptation come to be? That is the central theme of the book that Darwin chose to call 'The Origin of Species by means of Natural Selection, or the Preservation of favoured Races in the Struggle for Life,' and it was also the central theme of the greater part of his later writings. Darwin's answer was based on three main factors—(1) heredity, (2) variation, and (3) selection. No serious critic, I think, disputes that heredity and variation, as Darwin understood the terms, are both established facts of observation. The offspring repeats the characteristics of the parent, but the repetition is never absolutely exact.

In ultimate analysis the fact of *heredity* depends on two things—the cellular structure of organisms and the phenomenon of cell-division. When a living cell divides, its most essential substance, the germ-plasm, separates into two portions which are almost equal.

But we cannot so easily obtain an insight into the problem of variation. For simplicity's sake consider first the formation of a germ-cell from its mother-cell in an organism which is developing parthenogenetically. The researches of the colloid chemists have given us the picture. In imagination enlarge the germ mother-cell till you see the two phases; (1) the liquid, (2) the mass of molecular aggregates, varied in size and shape; till you see the long, complex chains of atoms building up the heavy molecules which form the aggregates; till you see the solar systems in miniature of protons and electrons which are the atoms. A seething, churning mass, active with the activity of cosmic forces, receiving matter and energy constantly from the surrounding medium, and giving them back. The preparations for cell-division begin; the molecular aggregates arrange themselves in new patterns; the separation of the cell into two parts ensues. Is it a matter for surprise that the partition of pattern and of substance is not always, perhaps is never exact? We cannot wonder that germ-cells thus produced differ in small respects among themselves. A few molecules more

were inherited, we should only have advanced a little way towards an understanding of our problem. The question *how* the soma influenced the factors in the germ-cell would remain. This has been realized clearly by Cunningham *, and he was the first who definitely put forward the suggestion that hormones, whose importance in the physiology of the higher animals had been demonstrated by the researches of Starling, provided an instrument capable of producing, as he thought, the required results. The idea is ingenious and suggestive, and might with advantage be followed up in future on experimental lines.

Vitalistic Theories.

The theories attempting to account for the adaptation of organism to environment which I have so far touched on have all been attempts to explain adaptation by the ordinary laws of physics and chemistry, of matter and energy; they have been essentially mechanistic.

The more elusive notions, which introduce the idea of some psychic or psychoid influence, controlling and regulating the processes of metabolism and organic growth, are difficult to deal with. I find it hard to distinguish them from the animisms of primitive man, who finds a spirit on every mountain, a devil in every bush. The influence is known by many names—vital activity, vital impulse, entelechy, élan vital, hormé, baumelodie, and urge. By its founder each is distinguished with great nicety from all the others, but I should fail were I to attempt to expound those distinctions here. All the ideas contain a suggestion of purpose, some of them an idea of almost conscious purpose such as we know only in ourselves, or by analogy assume in higher animals, in each case associated with an elaborately differentiated nervous system. They are brought into the story at the point where knowledge based on observation and experiment ceases, at the point where it seems to many of us more satisfactory frankly to say, I do not know.

Orthogenesis.

One other line of thought, which is constantly reappearing in discussions on organic evolution, I propose now to examine, the idea of Orthogenesis, the theory that the variations of organisms proceed in a limited number of predetermined directions, so that evolution itself is predetermined.

According to Bateson, it dates back at least to Lamarck, and Nägeli favoured it. In his essay of 1878, 'Evolution in Biology,' Huxley admits the possibility of the idea. "The importance of natural selection," he writes, "will not be impaired, even if further inquiries should prove that variability is definite, and is

* Arch. Entwick. mechanic, xxvii, 1908, p. 372.

determined in certain directions rather than in others, by conditions inherent in that which varies. It is quite conceivable that every species tends to produce varieties of a limited number and kind, and that the effect of natural selection is to favour the development of some of these, while it opposes the development of others along their predetermined lines of modification."

The same proposition was still further developed by Eimer, whose book, 'Organic Evolution as the Result of the Inheritance of Acquired Characters according to the Law of Organic Growth' was translated into English by Cunningham in 1890.

The Russian ichthyologist, L. S. Berg, in a book of great interest, packed full of little-known facts, an English version of which appeared in 1926 *, gives a modern discussion of the theory under the title "Nomogenesis, or Evolution determined by Law." Berg sets out definitely to overthrow Darwin's theory, and to furnish a substitute for it. As a destructive criticism of natural selection the attempt makes little or no appeal. As a modern statement of the theory of orthogenesis it possesses considerable importance, and draws attention to certain truths which, perhaps, have been too little emphasized.

To anyone who hopes to find a logical and rational interpretation of the order of the universe—rational from our human standard of thought, the only standard of thought we have—the theory of orthogenesis in its elementary form is certainly unsatisfying. An explanation of adaptations on these lines offers special difficulty, for the theory fails to provide the flexibility necessary to produce that constant adjustment of the organism to its ever-changing environment which is imperatively demanded. If, to reach the required adjustment, a predetermined direction of variations and evolution is postulated in the organism, a predetermined evolution of the environment on parallel lines would surely be equally necessary. What we find in nature is seldom, perhaps, an ideal perfection of fit, but rather a series of makeshifts, as one might almost say, a lot of cunning tricks and dodges, which give just enough adaptation to satisfy the survival test. Consider the locomotion of land animals, of the human biped. Efficient, no doubt, with a marvellous efficiency, for the purpose of moving over rough country, but the human invention of the wheel has pointed to still better possibilities.

Flexibility, modification of existing structure, now in this direction, now in that, is what organisms have need of, and a straightforward theory of orthogenesis or nomogenesis fails to meet the requirement. To circumvent the difficulty Berg, the latest protagonist of the idea, deals with this in a rather curious way. He tells us first that adaptations owe their development to inner causes inherent in the organism, and, secondly, that the environment effects the formation of new characters, transfiguring the forms in a determined direction.

* London, Constable and Co.

on this question, though, on the whole, his answer was yes. But he expressed his inability to decide how much influence the transmission of such characters had exerted on evolution. Weismann and his immediate followers, as you know, maintained rigidly that no proof of such transmission was forthcoming. The problem, to which I shall return later, is not yet beyond the range of controversy, and remains a lively question for debate.

A word may be said here about the term "fluctuations," which has been so much used in discussions about variation. It has, I think, ceased to be useful, and had better not be employed unless it can be defined in a more precise way than has yet been possible. Merely as a synonym for somatic modifications it seems unnecessary. Unfortunately in zoological literature there is still a certain amount of confusion in the ways of expressing the relations of the types of variation, though the correct ideas have, I believe, been thoroughly grasped by competent zoologists and botanists for many years past, and have been correctly taught in their schools. Endless debates by dialecticians have been based chiefly on differences in the way the ideas have been expressed. The whole matter is clearly set out by Goodrich in his most useful book 'Living Organisms' (Oxford, Clarendon Press, 1924).

In the light of what I have been saying, let us now consider the variations or deviations revealed by the measurements of biometricians, which group themselves around a mean or modal value, according to the "law of error." These deviations are the "individual differences" of Darwin, and this is what he says about them:—"These individual differences are of the highest importance for us, for they are often inherited, as must be familiar to everyone; and they thus afford material for natural selection to act on and accumulate"*. Darwin does not claim that they are always inherited, but says that they often are, and this I am inclined to think is the correct view, namely, that these deviations are in part small mutations which can be transmitted to decendants, and in part somatic modifications which are not so transmitted. It is quite impossible by any treatment of the measurements of a single generation to say what proportion of the deviations belongs to either class, nor does the biometrician make any claim to do so. What he does claim is that if he has adequate measurements for a series of consecutive generations the statistical tests which he applies enable him to say whether or not any of these deviations are inherited, and to give a measure of that inheritance. To take an example—it is frequently maintained that Johannsen's experiments with garden beans (*Phaseolus vulgaris nana*)†, which multiply by self-fertilization, and from which he obtained what he regards as pure lines, have proved that individual differences, as shown by these lines,

* 'Origin of Species,' 6th Edition, with additions and corrections to 1872 [1888], p. 34.

† 'Elemente der exacten Erblichkeitslehre.' Dritte Auflage. Jena, 1926, p. 179.

are not inherited, and that therefore they cannot provide material upon which natural selection can act. Pearson *, however, maintained, as long ago as 1910, that the pure-line theory demands that the offspring shall be as highly correlated with the grandparent as it is with the parent, whereas Johannsen's own figures show that the coefficient of correlation between offspring and parent is higher than that between offspring and grandparent. There appears to be no escape from this criticism, for the only doubtful feature about it is that Johannsen's figures are perhaps not sufficiently large to settle the question either way. The experiments require to be repeated with larger numbers of measurements, so that this important point may be more definitely established.

A development of recent times has been the realization that mutations may be classified into two groups, which have been called "combination mutations," those due to the rearrangement of genes or factors already present, and "alteration mutations," due to changes in the factors themselves. It is to be expected that some mutations of the latter class will, from time to time, arise merely from small inequalities in the partition of the germ-plasm at the time of cell-division. But another important question arises, namely, can the germ-plasm itself be directly or indirectly acted upon by physical or chemical changes in the environment in such a way that variations, or, to be more precise, mutations, are produced in the offspring—variations which are capable of being transmitted to future generations. Well-substantiated evidence is now, I think, forthcoming that the germ-plasm can be so acted upon. Hislop Harrison's † work on the production of melanic forms in Geometrid moths is so well known that only a brief description of it is called for here. The work is of outstanding interest, not only on account of the fundamental importance of the results attained, but also for its perfect combination of acute and penetrating observations in the field with critical and long-sustained experimentation.

The fact had for a number of years been recognized that many Lepidoptera in industrial districts, where the whole landscape is blackened by smoke, were appearing as dark, almost black varieties, whose tone harmonized with the darkened tones of the backgrounds on which they settled. It was to be expected that the first suggestion put forward was that here we had a clear case of the production of an adaptation, of a protective colouration, by which harmony with the background tended to concealment, and hence to escape from enemies.

But Harrison conceived the idea that the phenomenon might have been caused directly, by some chemical substance contained in the black deposit which covered the vegetation on which the larvæ of the moths and butterflies fed. Chemical analyses were

* 'Biometrica,' vol. vii, 1910, p. 371. 'Nature,' vol. 122, Dec. 1928, p. 954.

† Harrison, J. W. H., and Garrett, F. C. Proc. Roy. Soc. B. 99, 1926, p. 241; *ibid.* B. 102, 1928, p. 338.

made of the deposits, and it was found that salts of manganese were conspicuous constituents. He proceeded to make experiments, by adding to the food of larvæ kept under experimental conditions salts of manganese, the sulphate being used in the first experiments, and the chloride in a later series. Parallel experiments were made in which lead nitrate was used, and adequate controls were established in which the insects were fed on pure food.

The species experimented on was *Selina bilunaria*, a Geometrid moth, and the stock was obtained from non-industrial regions far from Northumberland, where the experiments were made. The pure food used in the controls was mostly leaves of hawthorn, and for the experiments themselves similar leaves either impregnated or sprayed with the metallic salts. Melanic moths appeared in the fourth generation in the lead cultures, in the second generation in the manganese cultures; the critical lead broods yielded three melanics and 53 types, the manganese brood eight melanics and 12 types. The controls in all cases gave nothing but normal type moths, and no melanics were known to have occurred in the strains used.

But the next step in the series of experiments enhances their interest and importance, for by adequate breeding tests it was demonstrated, without any possibility of doubt, that the melanic character was heritable and behaved in inheritance as a Mendelian recessive.

It is not necessary to go into more detail of the confirmation and extension of these pioneer experiments. Harrison has shown quite clearly that the germ-plasm can be changed by chemical substances contained in the food of an animal, or, in more general terms, that the germ-plasm can be altered by the environment.

It follows, too, that since the change, which was quite pardonably taken to be an example of protective resemblance, was in fact produced directly by chemical substances in the food, the "adaptation" to the surroundings is pure accident. It is, I suppose, most probable that the black pigment in the wings of these melanic moths is the organic compound melanin, whereas the dark colour of the smoky background is produced by particles of pure carbon. There is no rational explanation of why they should happen to fit. There is a certain touch of irony in the situation that, what is perhaps the first quite clear proof of a change, deliberately induced in an hereditary character, should have given a result like this. The lover of mystic views has his chance. Let him postulate an entelechy—a spirit of mirth, mocking mischievously the puny efforts of the biologist to solve the riddle of life.

Since the publication of Harrison's work another important advance in the same direction has come in H. J. Muller's account* of his production of mutations in *Drosophila melanogaster* by

* 'Science,' 66, 1927, p. 84.

irradiating spermatozoa in the males, or oöcytes and early oögonia in the females, with X-rays. When the correct dosage had once been found, mutations were produced in large numbers, and, although many of these were so-called "lethal mutations," there were many visible mutations as well, which, on the whole, were similar in their general characteristics to those previously reported in *Drosophila*. Some gave quite new morphological effects, but in the X-chromosome the majority of the well-known mutations, such as "white eye," "miniature wing," "forked bristles," etc., were obtained, some of them several times. Most of the mutations were recessive, but there were a number of dominants as well. "All in all," Muller writes, "there can be no doubt that many, at least, of the changes produced by X-rays are of just the same kind as the 'gene mutations' which are obtained, with so much greater rarity, without such treatment, and which we believe furnish the building blocks of evolution." Without at this stage adopting the belief expressed in the last sentence, which is not universally accepted, it is obvious that Muller's results, which have since been repeated in part by Weinstein * and others †, constitute a very important advance, and demonstrate that the germ-plasm can be definitely changed by external physical forces acting upon it, and that heritable variations can thus be produced.

One further point with regard to variations, already hinted at, I should like to consider before leaving the subject, though you may think it so obvious that it might well have been passed over in silence. The possibilities of variation of organisms are not infinite, but strictly limited and circumscribed. It has been too much the practice to think and speak of an infinite number of small variations upon which natural selection acts. The variations possible at any moment depend not only on the actual structure of the organism at that moment, but are still more rigorously limited by the general physical and chemical properties of the protoplasm of which the organism is built up. It is for this reason that recent advances in general physiology are of immense interest to students of evolution.

It becomes increasingly clear that the essential physiological processes, the physical and chemical processes upon which the life and activity of organisms depend, are comparatively few.

Digestion, growth, sexual activity follow the same general lines throughout the whole animal kingdom. Recent researches make it probable that the physico-chemical mechanisms of all muscular movement, of the movement of amœba by pseudopodia, and of the movement of cilia, will fall into one general scheme. Similarly the transmission of the nervous impulse, by which the actions of animals are co-ordinated, is being shown to proceed on essentially the same lines in animals of widely separated groups. One is

* 'Science,' 67, 1928, p. 376.
† *Ibid.*, 68, 1928, p. 59.

tempted to sum up the whole matter in a general statement, and to say all the essential physiological processes already function in the Protista.

If the physiological processes are few and circumscribed, it follows that variations in structure and form will be limited also, for, as a recent Russian writer* has well said, "form can be conceived only as a product of an inner physiological activity." This is a proposition which D'Arcy Thompson developed with abundant force and clearness in his book 'Growth and Form,' published in 1917, a book whose importance has been more recognized abroad than in this country.

Natural Selection.

It is now time that we turned to Natural Selection, the last of the three principal factors on which Darwin based his theory.

As an alternative title to the fourth chapter of the 'Origin of Species,' which deals with this subject, Darwin adopted a phrase suggested by Herbert Spencer, "the Survival of the Fittest." This introduces definitely the idea of adaptation. The fittest, those best adapted to the conditions of life, are those which survive, and survival is the test of fitness. Later, Ray Lankester suggested another formula, "the Elimination of the Unfit," and this, perhaps, describes more correctly the real meaning of the conception. There is no need to elaborate the idea, which has become one of the commonplaces of human thought: the immense fecundity of plants and animals; millions of eggs, as in many fishes, that two may on the average survive to reproduce their kind, one to represent the male parent and one the female. The facts of heredity and variation being what they are, to many of us it is difficult to reject the conclusion that this destruction is, at long last, selective; that any heritable variations which have the smallest survival value, however minute, however infrequently appearing—according to our ideas of infrequency—will be perpetuated, and any which are harmful will die out. That natural selection, acting on heritable variations, is a factor in the fixing of adaptations is almost a truism. But whether it is the only factor, whether it is sufficient by itself to account for the living things we know, each fitting so perfectly its own little niche in its world, is a more difficult question.

The process is of necessity so slow. But the time available is enormous, and geologists and physicists seem satisfied that it is to be reckoned in tens, if not in hundreds, of millions of years.

Then, again, we must consider whether the variations, the mutations, that occur are sufficiently diverse, and whether they are of kinds adequate for the task we are seeking to impose on

* Kusnetzov, 1920, quoted by Berg.

them, for it is clear that, if adaptations are to be selected, mutations in the direction of those adaptations, must occur. It has been maintained that by far the larger number of the mutations which have been studied are recessive characters, that they are due to loss of germinal factors, and that adaptations—or, indeed, any progressive evolution—could never result from their selection. This criticism, however, is not conclusive so long as we know that dominant mutations do occur; it merely reduces the number of mutations available for the production of adaptations.

The known mutations of *Drosophila* amount only to some four hundred, but the mutations so far selected for study are, for practical reasons, those which are large and obvious, and there is increasing reason to think that they are far outnumbered by small mutations which only long practice can detect. It may be noted also that a large proportion of the recognized mutations in *Drosophila*, in *Gammarus*, and in other forms which have been studied are colour-changes. This is because slight changes of colour can be distinguished with remarkable precision by the practised human eye. The changes in colour of pigments are due to slight chemical changes, and in working with colour-change what we are really doing is to use colour as an indicator for these chemical changes.

Correspondingly minute changes in size or shape could only be determined with the utmost difficulty, if at all. But very many adaptations are based on relative proportions of organs and parts, and mutations of this kind must always be hard to detect. On account of the difficulties of the research they have been little studied.

What has just been said obviously leaves the theory of Natural Selection in a somewhat unsatisfactory position. If I have correctly grasped it, the situation at the moment is that we must look chiefly to numerous small mutations for the material from which adaptations can be established by the process of natural selection, and no means are at present available of distinguishing these small mutations, excepting, perhaps, in the case of small colour-changes, from somatic modifications which are not heritable. It is not yet possible, therefore, to study these mutations by breeding experiments and the methods of Mendelian analysis. We can only form judgments about them by analogy with the results of work with larger and more distinct mutations, which can be subjected to these methods.

In these circumstances, the one course open is to continue to call to our aid the powerful instrument of statistical method, and to study mass populations of numbers of successive generations with all the assistance that mathematics can give. It is possible, as you know, not only to measure simple correlation, but formulæ are already available for both multiple correlation (for instance, bi-parental correlation) and for partial correlation. The method is one which is efficient, active, and advancing, and it can only be lightly disregarded by those who have failed to grasp its meaning.

Heredity of Somatic Modifications.

It is, I think, largely due to doubts of the adequacy of promiscuous hereditary variation to supply the material from which adaptations can be produced that so many biologists have favoured alternative or additional theories to account for evolution. Darwin himself, especially as he grew older, attached more and more importance to the idea of the inheritance of characters which had developed in the parent organism through constant use. Similarly he thought that disuse of an organ led directly by inheritance to the organ becoming rudimentary in the species.

This is a particular case of the general conception with which the name of Lamarck is associated, which is usually spoken of as "the inheritance of acquired characters." It is now recognized that this expression is not a good one, for, as I have already pointed out, all the characters of an organism may well be said to be "acquired" as a direct response of the developing organism to its environment. Graham Kerr * has recently used the phrase "impressed characters" for these somatic modifications, conveying the idea that characters which are in any way directly impressed on the body of the adult are, as it were, registered in the germ-plasm, which then becomes able, in a suitable environment, to reproduce similar characters in the offspring.

Does this, in fact, take place? Many naturalists have tried to get direct experimental evidence bearing on the question. There are some, as there have been since the days of Herbert Spencer, who are enthusiastically convinced, both from general considerations and from the results of experimental work, that an affirmative answer must be given. MacBride †, writing in 1926, says "few realise that in the last twenty years the fact that the results of habit are carried over into the offspring has been experimentally demonstrated by carefully devised crucial experiments," and he quotes the work of Kammerer on salamanders, on the mid-wife toad, and on the blind cave-newt, together with the work of Durkhen and Brecher on colour-changes in pupæ of butterflies. The latter work has since been repeated by Hislop Harrison ‡.

On the other hand, we have Graham Kerr §, writing in the same year, "There is, however, even today a good deal of nervousness about facing the problem of evolution without the potent aid that would be furnished by the transmission of impressed characters; and, curiously to my mind, many zoologists still take seriously sporadic laboratory experiments adduced to prove such transmission. As a matter of fact, we have going on around us involuntary experimentation on this subject on a scale so vast

* 'Evolution.' London, Macmillan and Co., 1926.

† Introduction to 'Biological Memory,' by E. Rignano. (Translation.) London, Kegan Paul, 1926, p. 6. See also 'Nature,' vol. 123, 1929, p. 980.

‡ Proc. Roy. Soc. B, 102, 1928, p. 347.

§ 'Evolution.' London, Macmillan and Co., 1926, p. 79.

as to dwarf any experimentation on a laboratory scale into a position of relative insignificance. I allude to the phenomena of inheritance in human beings. In man we have a species of animal whose individual peculiarities—structural, functional, psychical—are familiar to us as are those of no other creature. New peculiarities are constantly being impressed upon the individual by accident, by disease, by education, and so on. Every fresh individual that comes into the world is subjected to skilled and anxious scrutiny. Any repetition of a parental peculiarity at once excites the most lively interest.

"Is there any possible escape from the conclusion that, were it actually the case that impressed characters are transmitted, we should have before us a mass of evidence so overwhelming as to leave not the slighest doubt in any one's mind as to the occurrence of such transmission. That there is in point of fact no such mass of evidence, but that, on the contrary, the recorded cases in which such transmission is asserted are very few, is a fact which to the present writer appears to constitute entirely adequate reason for adhering to the view that such transmission does not take place."

So Graham Kerr states his case.

Goodrich * (1924) takes a similar view. After a clear exposition of the importance of distinguishing always between "factors" which are transmitted in the germ-plasm and "characters" which are inherited, that is, are developed in the adult as a result of the response of the "factors" to the stimuli which make up the environment, he writes:—

"Modifications, then, are not transmitted as such. In the absence of the stimuli which originally gave rise to them they could only reappear if the new environment produced such a change in the factors of inheritance themselves, that, when replaced in the old environment, they continued to respond as if the new stimuli were still present. This is what the Lamarckian theory of evolution demands. We will not say that such a thing is impossible; but it is in the highest degree improbable, and it is very difficult to conceive how such a result could be reached. At all events, no case of the supposed transmission has yet been brought forward which could not be better explained in other ways."

And, in a footnote, Goodrich adds:—"The real question Biology has to answer in future, as O. Hertwig has pointed out, is not 'Are modifications inherited?,' but 'How are new factors acquired?'."

The two views, then, remain as sharply in conflict as they were forty years ago, when Herbert Spencer on the one side and Weismann on the other stated the issue with clearness and precision.

Even if it could be proved experimentally, without possibility of question, that somatic modifications or impressed characters

* 'Living Organisms.' Oxford, Clarendon Press, 1924, p. 62.

were inherited, we should only have advanced a little way towards an understanding of our problem. The question *how* the soma influenced the factors in the germ-cell would remain. This has been realized clearly by Cunningham*, and he was the first who definitely put forward the suggestion that hormones, whose importance in the physiology of the higher animals had been demonstrated by the researches of Starling, provided an instrument capable of producing, as he thought, the required results. The idea is ingenious and suggestive, and might with advantage be followed up in future on experimental lines.

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* London, Constable and Co.

In order not to misrepresent his views I quote the following passage :—" Characters occur which owe their development to inner causes, inherent in the very nature of the organism, which we call *autonomic*, independently of any effects from the environment. These autonomic causes are connected with the stereochemical properties of the albumens of the protoplasm of the given organism, which induce the latter to develop in a determined direction. It is obvious that characters originating through autonomic causes are, as a rule, adaptive. But in addition to such an unfolding of pre-existing rudiments, *the formation of new characters* takes place; and this is due to the effects of the geographical landscape, which also transfigures the forms in a determined direction" *.

That evolution proceeds according to laws of the same character as other laws of nature is the common basis of all modern evolutionary theory, and was held, perhaps, more strongly by Darwin, Huxley, and Weismann than it is by some writers of to-day. When Darwin uses the word "chance" he knows, and has explained clearly, what he means. He implies nothing more than that the causes are unknown, or not sufficiently known.

The laws in accordance with which variations and adaptations occur have been sought diligently by two generations of biologists since Darwin spoke, and all biological researches of today, whether of the systematist, the field-naturalist, the morphologist, the embryologist, the experimental biologist, or the palæontologist, what are they but many-sided endeavours to unravel these laws?

One great law of evolution on which much light has come, especially since Bateson wrote, is Mendel's Law, the study of which has so stimulated research during the last twenty years. Others are more dimly seen and await experiment, as D'Arcy Thompson's 'Growth and Form,' to which I have already referred, makes clear.

The physical laws in accordance with which the processes of growth are controlled, with results that we see in so many curious patterns, from the simple branching of a tree or of a nerve-fibre, to the elaborate spirals of a shell or a growing plant; or, again, the laws which lie behind the varied shapes, so curious and wonderful, of organism and of their different parts—these laws, and many others like them, still call for serious consideration and research. This is the valuable feature of the theory of orthogenesis, and in drawing renewed attention to it, its followers make a valued contribution to biological thought.

May I read you yet another quotation, this time from D'Arcy Thompson †:—

" For orthogenesis is simply that phenomenon of continuous lines or series of forms (and also of functional or physical capacity) which was the foundation of the Theory of Evolution, alike to

* Berg, L. S., 'Nomogenesis.' London, Constable and Co., 1926, p. 403.
† 'On Growth and Form.' Cambridge University Press, 1917, p. 549.

Lamarck and to Darwin and Wallace, and which we see to exist whatever be our ideas of the 'origin of species' or of the nature and origin of 'functional adaptations.' And to my mind the mathematical (as distinguished from the purely physical) study of morphology bids fair to help us to recognise this phenomenon of orthogenesis in many cases where it is not at once patent to the eye; and also, on the other hand, to warn us, in many other cases, that even strong and apparently complex resemblances in form may be capable of arising independently, and may sometimes signify no more than the equally accidental numerical coincidences which are manifested in identity of length or weight, or any other simple magnitudes."

"For," as he says later *, "the harmony of the world is made manifest in Form and Number, and the heart and soul and all the poetry of Natural Philosophy are embodied in the concept of mathematical beauty."

This, then, is the truth behind the theory of orthogenesis—evolution according to law.

There are many other aspects of the problem of the origin of adaptations with which I might have tried to deal—the effects of isolation, especially of island conditions, the phenomena of convergence and of parallel induction, of the influence of endocrine secretions on growth, or of the intraspecific selection which Poulton † has recently discussed—but it has seemed to me better to confine myself to the larger questions, even at the risk of telling you nothing but what you knew already quite well. The main roads at times get overgrown with a tangle of detail, and it is well to try to clear them.

But my general conclusion is, I fear, a lame one. To the question, how do adaptations arise, how does the organism bring itself into that intimate, yet by no means perfect, adjustment with its whole fluctuating physical and biological environment, which suffices for survival, we cannot yet give a certain answer. Natural Selection, as conceived by Darwin and Wallace, still seems to most competent biologists a potent factor, but the number who regard it as all-sufficient would seem to be diminishing. We must even face fearlessly the possibility that the whole conception must be abandoned as a main cause of organic evolution.

The group of Lamarckian doctrines—inheritance of somatic modifications, of the effects of use and disuse of parts—however much such ideas may entice as a simple solution of these complex problems, they have yet to receive conclusive proof; and even if that proof were forthcoming, we are still no further than the threshold of our question, How?

Orthogenesis, nomogenesis, evolution according to predetermined law, and similar concepts rest upon a great truth, which, though implicit in the doctrine of nearly every writer on evolution,

* *Ibid.* p. 778.

† Proc. Zool. Soc. part 4, 1928, p. 1037.

is not always clearly discriminated and defined—the truth that the possibilities of evolution are not infinite, but are rigidly determined and circumscribed by the physical structure of the matter, organic and inorganic, of which the bodies of plants and animals are built up, and by those particular natural forces through which their activities are controlled.

Of supposed explanations based on ideas of vitalism or entelechy my personal view is that they are no explanations at all. They seem merely an abandonment of the problems as insoluble, an endeavour to hide ignorance with a word. The one thing above all others to avoid is to mistake words for knowledge.

But I would not end on a note of defeat. The outlook for biology to-day is as alluring and as full of hope as it was in those years of joyful enthusiasm which followed 1858. In whatever direction we look problems bristle, problems open to successful attack; and the old qualities—insight, patience, and determination—will get them solved. But we must not limit the outlook. The greatest lesson I have learned by my own particular bit of experience is that all aspects of biological research must proceed hand in hand. Botany, zoology, palæontology, the work of the systematist and of the field-naturalist, the study of structure and the study of function, the work of the embryologist and of the experimental physiologist, of the geneticist, and of the statistician, all are necessary, and none can succeed without the others.

OBITUARY NOTICES.

Victor Ferdinand Brotherus, whose death took place on 9th February, 1929, has been long acclaimed, indeed since the passing of Carl Mueller, of Halle, as *princeps* among bryologists. He was born in the Aland Islands, where his father held a position as an intendant of the military stores. He graduated Bachelor of Arts and Doctor of Philosophy at the University of Helsingfors, and while a student there he came under the influence of S. O. Lindberg, Prof. of Botany, and was thus led to the study of mosses. On leaving the University he became a teacher of Natural Science and Mathematics in a public school in Helsingfors, a position which he held for almost forty years. He held no university offices; all his scientific work was done at home as a private student. The title of Professor was an honorary one, bestowed on him by the Finnish Government in 1921. He was an honorary member of several of the leading European scientific societies. In 1927 the dignity of Doctor *honoris causa* was conferred on him by the University of Bonn.

A subvention from the Imperial Academy of Science, St. Petersburg, made possible scientific journeys to the Caucasus in 1877 and 1884, resulting in his treatise on the Distribution of the Mosses in the Caucasus. In 1896 he undertook a long journey into Central Asia, where he made large collections.

During his long life he published nearly 100 books and papers on bryophytes from all parts of the world, and, indeed, he might well have said, from the point of view of mosses, that the world was his parish. The number of new species described by him must have run well into four figures, and most of these may be expected to stand, while his descriptions were for the most part marked by clearness and accuracy.

His outstanding work was the elaboration of the mosses (Andreæales and Bryales) for Engler & Prantl's 'Pflanzenfamilien,' published from 1901 to 1909, a second edition appearing in 1924–25. 'Die Laubmoose Fennoskandias,' published during his later years, was the fruit of long and careful work.

His name is commemorated in the genera *Brotherella*, *Bryobrothera*, and *Bryobrothera*. His herbarium is estimated to include upwards of 15,000 species, represented by fully 110,000 specimens.

He was elected a Foreign Member in 1920. H. N. Dixon.

Professor John Merle Coulter (1851–1928) was the leading botanist of his time in America, his influence being greatly extended by the building up of a large and successful school of botany at the University of Chicago, and by the founding in 1875 and editing for fifty years of the 'Botanical Gazette,' which became the leading medium in the United States for the publication of botanical investigations.

Professor Coulter was born in Ningpo, China, the son of a missionary, who died two years later. His mother then returned to Hanover, Indiana, where the young son received his early education. He received the B.A. degree from Hanover College in 1870 and the Ph.D. from the University of Indiana in 1882. His teaching career began at a local academy, and he was successively Professor of Natural Science at Hanover College (1874–1879), Professor of Biology at Wabash College (1879–1891), President and Professor of Botany in the University of Indiana (1891–1893), and President of Lake Forest University, Illinois (1893–1896). When the new University of Chicago was organized in 1896, and leading men from all over the country were chosen as heads of the various science departments, he was called to preside over the Department of Botany, together with Whitman in Zoology, Michelson in Physics, and Nef in Chemistry.

It was in this connection that Coulter attained his widest influence. His soon became the leading botanical laboratory in the country, devoted especially to morphology and cytology, and, in association with Prof. Charles R. Barnes, to physiology and ecology. The latter was, I believe, the only member of his staff whom Coulter had not trained himself. A school of botany was developed which became known throughout the botanical world, and trained large numbers of botanists, many of whom have taken leading rank in their science.

After a period of nearly thirty years at Chicago, Professor Coulter retired in 1925. He was a great teacher, who inspired his students with the desire for research. His lectures were characterized by lucidity, compactness of expression, and a fine sense of proportion. He never allowed his enthusiasm for imparting information to outrun his conception of the amount of knowledge which his particular hearers were capable of digesting.

Although almost every phase of botany was cultivated at Chicago, yet Coulter's own botanical development falls clearly into two periods. He began as a taxonomist, was botanist to the Hayden Survey Expedition in the Western Territories in 1872, when he studied the flora of the Yellowstone and adjacent regions, and became the friend and pupil of Asa Gray. This afterwards led to his producing, with Watson, the sixth revised edition of Gray's 'Manual of Botany'. In 1885 he published his 'Manual of the Botany of the Rocky Mountain Region,' and in 1892–93 a 'Manual of Texan Botany.' His contributions to taxonomy continued with papers on the Cactaceæ, and his taxonomic period may be said to have ended at the turn of the century, with a monograph published jointly with Dr. J. N. Rose in 1900 on the Umbelliferæ of North America. But his interest in taxonomic botany never terminated, and at the time of his death he was engaged in writing a series of taxonomic articles for the 'Encyclopædia Britannica,' which were to include a world-wide survey of various important families.

His establishment as head of a large botanical laboratory no doubt turned Dr. Coulter's attention to the need for developing morphology, and during the Chicago period his interests were primarily in that field. An ever-widening stream of papers, chiefly morphological, began to appear from his laboratory. Many of these results were incorporated in two widely-used volumes, written in collaboration with Prof. C. J. Chamberlain, 'Morphology of Angiosperms' (1903) and 'Morphology of Gymnosperms' (1910).

Throughout his active life Coulter maintained a variety of other interests. He kept in close touch with the secondary schools of his country, and wrote a series of small text-books on plants, which were of notable service in popularizing the teaching and study of botany in schools. A ready speaker, he was much in demand for addresses at college and university functions and celebrations. He maintained an active interest and connection with the Presbyterian Church, and in his later years published a number of articles in religious journals.

After his retirement, in 1925, Professor Coulter acted as scientific adviser to the Boyce Thompson Institute for Plant Research, which he was largely instrumental in founding, at Yonkers, near New York. In 1923, at the age of 72 years, and before his retirement, he made a lecture-tour through China and Japan at the instance of the National Association for the Advancement of Education, visiting the principal colleges and universities of the Orient, and giving addresses. He expressed a deep interest and belief in the future educational development of the Chinese people.

Professor Coulter married in 1874 Miss Georgia M. Gaylord, and he has two surviving sons, both of whom received a botanical training, and two daughters. Among the numerous honours that fell to him it may be mentioned that he was President of the American Association for the Advancement of Science in 1918, and a member of the National Academy of Sciences, President of the Botanical Society of America in 1897, and again in 1915, of the Illinois State Academy of Science in 1910, and the Chicago Academy of Science in 1916–24, of the American Association of University Professors in 1918. He was elected a Foreign Member of the Linnean Society in 1921. Coulter's contribution to the history of botany is more, perhaps, as a great teacher and inspirer of research than as an original thinker in biological fields. As a teacher and producer of botanists he had few equals, and the activities of himself and his pupils have made a deep impression upon botanical research in America. R. R. Gates.

Helen Mary England (1880–1929) was born near Manchester in 1880. She was for two years at St. Leonard's School, St. Andrews. Then followed four years at Manchester University, where she took the B.Sc. degree with honours in Zoology in 1902. After her degree she worked for about two years in Professor S. J. Hickson's laboratory. As the result of this she published, in conjunction

with Professor Hickson, in 1905, a pamphlet on "The Stylasteridæ of the 'Siboga' Expedition." The rest of her zoological work was microscopical research into the structure and development of the same group of hydrozoan corals. She published the results of it in 1926 in the form of a paper read before the Zoological Society of London on "The Development of Gonophores of the Stylasteridæ."

She died, after a long and trying illness, on February 16th, 1929. E. B. E.

Hugh Findon (1871–1929), who died on February 18th, 1929, at Church End, Finchley, Middlesex, was born on August 11th, 1871, in London, where he spent his life working with his father and sharing with him the business of builder and house decorator.

Having inherited from his grandfather, Orlando Jewitt, of Oxford, a collection of shells, it became his great aim in life to make this collection as complete as possible.

He set himself to gather suitable specimens from all parts of the world, both by exchange and purchase, the result being that in the course of time the Findon collection of recent and fossil mollusca became well known and greatly appreciated at home and abroad.

Although greatly handicapped by partial paralysis of the right side, the result of an accident in early childhood, our late Fellow was a most capable and accurate workman, as shown in the designing and the making, among other things, of a suitable and handsome cabinet of hardwood, Tasmanian blackwood, in which to store the collection that had been formed by representatives of three consecutive generations—grandfather, father, and son.

Hugh Findon was elected a Fellow on March 1st, 1906, and until his last attack of illness was frequently present at the Society's meetings. He became a member of the Hampstead Scientific Society soon after its inauguration (1899), and subsequently was elected Secretary for Natural History, acted for several years as the representative of the society at the annual congress of the South-Eastern Union of Scientific Societies, and during five consecutive years (1924–28) was the referee for Mollusca (recent and fossil).

Latterly he was engaged in comparing classifications. He brought them together, and closely examined the opinions of the leading authorities on the subject, and thereon began to write his own ideas upon the matter; but the effects of his early trouble began to show itself in loss of memory and lack of mental concentration.

A serious accident in 1926 was the cause of his last illness; it deprived him of the sight of one eye, and was a serious shock to the system generally.

I am deeply indebted to Miss Ruth Findon for giving me certain facts concerning the last two years of her brother's life.

Full of enthusiasm, bright and cheerful in manner, he was always ready to help those who sought information respecting subjects with which he was well acquainted. R. Paulson.

The Rev. James Lamont (born at Crathie, 11th July, 1844, died at Edinburgh, 28th August, 1928) was interested in nature as a boy, and his meeting with Dr. William Carruthers in his theological student days made that interest prevailingly botanical. He was ordained in 1871 as minister of the Presbyterian congregation at Portsmouth. In 1873 he went to Union Chapel, Hong-Kong, as successor to the famous Chinese scholar Dr. James Legge; and at the suggestion of Dr. Carruthers he made a considerable collection of Chinese plants, which are in the British Museum. Among them were several new species, and two or three of them bear the specific name *Lamontii*. Most of his active life was spent in the Presbyterian Church of New South Wales, which did him the highest honour in its power, making him its Moderator in 1895; he collected in that part of the world also, and the plants are in the British Museum. He did good war-work in England as Chaplain, with rank of Major, in the Australian Forces; and after retiring to Edinburgh he made a remarkably complete collection of British mosses, mounted with his peculiar neatness of hand and precision; these also are in the British Museum.

S. W. Carruthers.

Jakob Wilhelm Leche (1850–1927), whose death occurred in Stockholm on Jan. 29th, 1927, was born at Helsingborg, in Scania, the southernmost province of Sweden, Sept. 4th, 1850. His father was then postmaster in the city mentioned, but when the boy Wilhelm was six years old his father was appointed as Swedish Consul-General in the old Hanseatic City of Lübeck, and the family moved with him there. Thus it happened that Wilhelm Leche was educated in German schools until he reached the age of 15 years. During this period naturally enough he acquired a German accent, which remained to a certain extent even after he was a grown man. From the age of 15 he went to school at Lund in Scania until he matriculated (1870) as a student at the university there. He partook eagerly in college-life as a jolly student. He was a good singer and interested in music; also in social and political questions, and was not unjustly regarded as rather radical. He did not, however, in spite of his side-interests, neglect his scientific studies, but passed the examination as Cand. Phil. 1875, and graduated as Ph.D. 1877. In the previous year he had been nominated as assistant teacher (Docent) in zoology at the university. In the year 1877 he went abroad to study in Heidelberg, Munich, and Berlin. In Heidelberg the famous Gegenbaur was professor, and during his studies there Leche took very deep impressions from him, so that it might be said that he belonged to the Gegenbaur school almost all his life.

It had long been planned to found a high school in Stockholm at which scientific studies might be carried on with more freedom and without certain conditions and restrictions which necessarily must be connected with the old state universities. When these plans appeared to be near their realization, about 1880, Leche went to Stockholm, and received an appointment as teacher in zoology *ad interim* at this just-developing high school. In the year 1884 the funds permitted a professorship in zoology to be instituted, and Leche became the first occupant of this chair, which he kept until 1918, when he retired with a pension.

It is evident that, to begin with, he had many difficulties to overcome. He was obliged, in the first place, to arrange and organize a laboratory and furnish it with the necessary instruments and collections, etc., although the means at his disposal were small and often insufficient. Nevertheless he was successful, and he also found donors who assisted him in several ways. After ten years, he had obtained a very good collection of skeletons, mostly mammalian, which continued to increase, and also other collections and material for researches in comparative anatomy. It was almost exclusively such investigations that were carried on in his laboratory, so that he named it "the zootomical institute,"—not "zoological".

Leche's dissertation, by which he obtained the degree of Doctor of Philosophy, was a treatise on the milk-dentition and the homologies of the teeth of the Chiroptera, which was much appreciated. It may be said that this was the inauguration of his future work, because afterwards he devoted much time and work to the study of similar questions. Among his numerous papers on similar subjects may be mentioned the following:—"Studien über die Entwicklung des Zahnsystems bei den Säugethieren" (Morph. Jahrb. Bd. xix, 1892); "Zur Entwicklungsgeschichte des Zahnsystems der Säugethiere.—Theil 1. Ontogenie" (Zoologica, Bd. vi, Heft. 17, 1894–95); "2 : 1. Phylogenie, Familie Erinaceidæ" (*ibid.* Bd. xv, Heft. 37); "2 : 2. Die Familien Centetidæ, Solenodontidæ, und Chrysochloridæ" (*ibid.* Bd. xx, Heft. 49, 1907); and, further, "Zur Frage nach der stammesgeschichtlichen Bedeutung des Milchgebisses bei den Säugetieren" (Zool. Jahrb., Abt. Syst. Bd. xxviii, 1909, and II. Bd. xxxviii, 1915). In these papers Leche discusses the phylogenetic origin of the mammalian teeth, the homologies of the dentitions, and several other questions. All his views have not been accepted, but it must be admitted that he has greatly contributed to the knowledge of many important questions concerning the dentitions of the mammals. This class attracted him more than any other within the animal kingdom, and the Insectivores especially were his favourites and aroused his interest more than any others. In addition to several papers on their dentition, he wrote also on the anatomy of their pelvic region with regard to its relationship to the corresponding parts of other mammals (K. Vet.-Akad. Handl., Stockholm, Bd. xx, 1883). Another paper of importance is entitled "Ueber die

Säugethiergattung *Galeopithecus*" (*ibid.* Bd. xxi, 1896), being a morphological study of this genus. In another paper he discussed the dentition of living and fossil Lemurids (1897), not to mention several other minor papers on different anatomical features of marsupials, etc. In consequence of Leche's great reputation for a wide knowledge of the morphology of mammals, he was invited to take up and continue the work on this class in 'Bronn's Klassen und Ordnungen des Thierreichs' (after Giebel). Between 1884 and 1897 he completed and edited parts 27–64 of this work, after which Göppert's name appears on the title-page.

For systematic zoology Leche had only little interest. He was, however, author of a couple of papers on arctic molluscs, of minor importance, and he wrote also a few descriptive notes on mammals.

His interest in the popularization of the science was very keen, and he wrote numerous zoological articles in an encyclopædic work. A popular book by him on 'The Origin and Development of Man' has been much appreciated by the public, so that two editions have appeared in Sweden (1909 and 1911), and, at the same time as the latter, also one in Germany.

He was a very good teacher, and his scientific lectures were vivid and clear. He loved to teach his scholars and give them valuable advice for their work. Leche did not, however, restrict himself to teaching and lecturing at the high school, but, being an ardent supporter of public education, he used also to lecture for working men at an institute which had been founded at Stockholm for such a purpose. In the year 1887 he was elected a member of the board for this institute, and acted as President of this board between 1897 and 1922.

An intimate friend of his praised him for his acuteness and his wide interests. "He loved his scientific work, but he had at the same time an open mind for many other things and for public affairs. He was a personality, sharp in his criticism and warm in his admiration, a charming man among his friends, an entertaining narrator, and a master of repartee."

He was elected a Foreign Member of the Linnean Society on the 4th May, 1922. E. Lönnberg.

The Rev. Marcus Samuel Cam Rickards (1840–1928), died at his residence, The Retreat, Clevedon, Somerset, on February 26th, 1928, in his 88th year. He was born at Exeter on April 28th, 1840, and was the youngest son of the late Robert Hillier Rickards, D.L. and J.P., of Llantrissant House, Glamorgan. He was registered as a solicitor in 1862, and practised in Bristol and Clifton for thirteen years under the style of Rickards and O'Donoghue, and after that he relinquished law for the church. Passing from Merton College, Oxford, in 1875, with Third Class Honours in Theology, for his B.A. degree, he was ordained in the same year, becoming priest a year later, and M.A. in due course. He was first licensed to the curacy of Holy Trinity, Clifton, where he

stayed fourteen years; and in 1889 he accepted the living of Twigworth, Gloucestershire, which he held until his retirement in 1912, when he took up his residence in Clifton, and subsequently in Clevedon.

A man of high literary taste and attainments, Rickards was a poet of distinction and a Vice-President of the Poetry Society. He published some forty volumes of poems for private circulation, and his subjects at first (from 1889–1913) were sonnets and lyrics dealing with Nature, and included "Poems of a Naturalist"; but after that, until 1918, biblical subjects occupied his verse.

He joined the Linnean Society in 1871, whilst still a solicitor, and during his long life contributed many articles to natural history periodicals, chiefly on ornithology.

Of an affable disposition, the reverend gentleman mingled with his chosen friends, and was held in high esteem by the residents of Clevedon. His wife, Edith Elizabeth Anson, after 62 years of married life, predeceased him by twelve months, and two sons and a daughter survive. IDA M. ROPER.

MRS. HENDERINA (RINA) VICTORIA SCOTT, who died suddenly on Jan. 18th, 1929, was elected a Fellow of the Society in 1905, being among the earliest groups of women to be admitted to the Fellowship.

As a student at the Royal College of Science in 1886 she attended the advanced classes in Botany, which at that time were being held at the Jodrell Laboratory, Kew, by Dr. D. H. Scott. This auspicious association led to their marriage the following year. As the wife and constant companion of a great botanist, Rina Scott found a position which gave full scope to her fine social gifts. The Scotts' home became a place where botanists, young and old, foregathered. Indeed, Mrs. Scott's knowledge of, and sympathy with, the interests of her friends was quite remarkable, and her death is widely lamented. She and her husband made their home first at the Old Palace, Richmond, and, on Dr. Scott's retirement from the position of Hon. Director of the Jodrell Laboratory in 1906, at East Oakley House, near Basingstoke. This latter was an old farmhouse converted to their requirements, and here Mrs. Scott was often to be found in apron and gloves attending to one of her rose-gardens, or elsewhere in the beautiful grounds which arose in obedience to her will. What she did for botanists, she did also for her neighbours, relations, and other friends.

Nor did these calls upon her energies (which were boundless) ever distract her from the pursuit of botany itself. Her first piece of investigation concerned the nucleus-like bodies in the cells of the blue-green Algæ *Oscillaria* and *Tolypothrix*; and, although the paper itself was written by Dr. Scott (Journ. Linn. Soc., Bot. vol. xxiv, 1888), full acknowledgements are made to the work of Miss H. V. Klaassen, as she then was. Other contributions, as was natural, were in the field of fossil botany. These include a short article "On the Megaspore of *Lepidostrobus*

foliaceus" (New Phytol. 1906); "On *Bensonites fusiformis*" (Ann. of Bot. 1908), and another on the curious sporangial bodies called *Traquairia* (Ann. of Bot. 1911). Mrs. Scott took a large share in the indexing and cataloguing of her husband's collections of fossil-slides—a most valuable effort. She also collaborated with the late Ethel Sargant in an investigation on the development of *Arum maculatum* from the seed (Ann. of Bot. 1898).

On the physiological side she made a detailed study of the movements of the flowers of *Sparmannia africana* (Ann. of Bot. 1903), which she also demonstrated by means of the cinematograph—then in its infancy in application to scientific purposes. In the field of moving pictures as applied to plants Mrs. Scott was a pioneer, and demonstrated her results (obtained from plants raised in her own greenhouse) to the Linnean Society and elsewhere (paper in 'Knowledge,' May 1904).

Outside Botany Mrs. Scott had a wide range of interests, many of them dictated by a warm and generous heart.

As some indication of Mrs. Scott's activities in local affairs it may be mentioned that she was elected to the Wootton St. Lawrence Parish Council in 1913, becoming Chairman in 1924. She also served on the Basingstoke Board of Guardians and Rural District Council, and acted on numerous committees. She was also a Manager of the Oakley and Deane School, and, as Treasurer, was extremely active in raising funds for the building of a new schoolroom in 1924.

Towards the close of her life she was much interested in Christian Science, in which cause she gave much service.

F. W. Oliver.

The death on 23rd December, 1928, at The Ferns, Witcombe, Gloucestershire, in his 86th year, of Sir William Turner Thiselton-Dyer has deprived our Society of one who had for fifty-six years been among the most eminent of its Fellows: he became a member on 15th February, 1872; served on the Council during 1874–6, and again during 1884–7, in 1885–7 as a Vice-President.

Born in Westminster on 28th July, 1843, Dyer was educated at King's College School, and, on matriculating in the University of London, entered King's College, whence he went up, as a Junior Student, to Christ Church, Oxford. Though joining as a classical scholar, he graduated in 1866 in the Mathematical School, and, remaining in residence after taking his degree, obtained a first-class in the Oxford Final Natural History School in 1867.

Appointed to the Chair of Natural History in the Royal Agricultural College, Cirencester, in 1868, Dyer graduated as B.Sc., London, in 1870, and was then elected to the Chair of Botany in the Royal College of Science, Ireland, which he held till, early in 1872, he became Professor of Botany to the Royal Horticultural Society of England, at South Kensington and Chiswick. This position brought him into personal contact with Dr. J. D. Hooker, then Director of the Royal Botanic Gardens at Kew, whom he

assisted in preparing one of the earlier parts of the Flora of British India, and with Prof. T. H. Huxley, then occupant of the Chair of Biology in the Royal School of Mines, who made Dyer one of his demonstrators, and entrusted to him the organization of a special botanical course of instruction for teachers. In 1875 Dyer was appointed Assistant Director of Kew, and in 1877 he married Harriet Anne, eldest daughter of Dr. Hooker. The outstanding value to our colonies and dependencies of Dyer's work at Kew was recognized in 1880 by his election to the Royal Society, in 1882 by his being created C.M.G., and in 1885 by his appointment as Director of the Royal Botanic Gardens on the retirement of his father-in-law.

As a schoolboy and undergraduate Dyer had been a keen field-botanist; he collaborated with his former class-fellow, Dr. H. Trimen, in the preparation of their 'Flora of Middlesex', published in 1869. His collaboration while at Cirencester with his colleague, Prof. A. H. Church, in editing for use in this country a special issue in 1869 of the work by Prof. Johnson of Yale entitled 'How Crops Grow,' is evidence that his interest in the plant as a mechanism was as marked as his interest in plants as organisms. His capacity as a teacher was shown at Cirencester, at Dublin, and more especially at South Kensington, where, as a colleague of Prof. Huxley, he was a pioneer in providing this country with a new type of botanical instruction. He rendered his fellow-teachers a further service by collaborating with Mr. A. W. Bennett in supplying them with an English edition, which appeared in 1874, of the 'Text-book of Botany' by Prof. von Sachs, while his contributions to the 'Flora of British India,' also published in 1874, gained for him an assured position as a competent systematist. His work as Assistant Director of Kew during 1875–85, proved him to be an economic botanist of singular foresight and an executive officer of sound judgment, wise courage, and prompt decision.

As Director of Kew during 1885–1905 Dyer showed all the qualities of a consummate landscape-gardener, whose power to constrain nature was only equalled by the skill with which he concealed art, and displayed administrative gifts that, if possible, surpassed the executive powers so manifest earlier in his career. His work on behalf of India was recognized in 1892 by his being created C.I.E.; that on behalf of our colonies was rewarded by his being promoted K.C.M.G. in 1899.

Until 1890 Dyer took his full share of those public duties that naturally fall to men of science: after that date pressure of official work compelled him to refrain from undertaking tasks, outside his duties as Director of Kew, other than those imposed on him by government departments.

After his retirement Dyer took an active part until 1916 in the business of the county of Gloucester, for which he had been appointed a Justice of the Peace, and continued certain editorial tasks undertaken by him while still Director of Kew; any available leisure was devoted by him to a renewal of his early classical

studies in response to a request for help in the elucidation of botanical problems made by the scholars engaged upon a revision of the great Greek lexicon of Liddell and Scott.

In 1916 failing health induced Dyer to lay aside county work and to terminate his connection with most of the learned societies, including the Royal Society, to which he had belonged; one of the few societies excepted was our own Society. From then onwards, till his death, his attention, when health permitted, was concentrated on those classical studies the results of which owe their value to letters and science alike, to the happy, if unusual, combination in Dyer of the qualifications of the scholar and the naturalist. D. Prain.

Arthur William Waters, for over fifty years a Fellow of the Linnean Society, died at Bournemouth on February 20th, 1929, in his 83rd year.

Born at Alderley Edge, near Manchester, of a highly respected family connected with engineering, he received part of his early training at Owens College before it received its charter as Victoria University. He always retained feelings of gratitude and affection for his old college, leaving to it the whole of his valuable and extensive scientific collections of fossil and recent Bryozoa (Polyzoa) and a very complete library of literature on his special subject.

Early in life he developed lung trouble, and this fact influenced the whole of his career; for in his 20th year he was compelled to seek a climate suitable for his health. He was one of the first sufferers to try the high-altitude cure at Davos, subsequently visiting Heidelberg to continue his studies; but for many years he found it advantageous to make Davos his home and headquarters. He lived for a time in the house (Villa Vecchia) in which the Davos hero Georg Jenatsch (1634) had dwelt. Here Mr. Waters worked at many subjects, viz., Geology, Archæology, Botany, Meteorology, and local History, writing papers in English, French, and German; but presently he began to interest himself especially in fossil Bryozoa. He tramped over large areas of Switzerland, S. Germany and N. Italy, studying chiefly the Tertiary formations, and making large collections of fossils that he sorted and cleaned himself. More than once in the course of his rambles, when sketching, he was arrested as a spy or anarchist, his microscope being taken for an infernal machine, and the owner marched off to the mairie between frontier-guards—a situation that must have appealed to the sense of humour of this kindly straightforward Englishman.

Over forty-five years ago he presented to his old College his collections of fossils, sending them down the Rhine in a barge, and from the English coast in a motor-van to Manchester.

He now took up the study of recent Bryozoa, collecting in Mediterranean localities and visiting the marine laboratories at Naples, Villefranche, and Monaco, also colleagues and museums in Denmark and Sweden, and especially the British Museum (Nat. Hist.).

The numerous papers recording his results, and published in the journals of the Linnean, Geological, Zoological, and Royal Microscopical Societies, Ann. & Mag. Nat. Hist., &c., &c.. fill nine octavo volumes. Larger memoirs and monographs include a supplementary 'Challenger' Report and a fine volume on the Bryozoa of the 'Belgica' Antarctic Expedition.

In nearly every instance, the drawings of the very numerous plates were done by himself, and occasionally even the lithographic work. He was ably assisted by his wife, well known as an expert in photography.

In the course of critical observations (Proc. Zool. Soc. 1913, p. 460), on Levinsen's 'Morphological Studies. . . .' Mr. Waters indicates the leading principles that had influenced himself in his own work. He writes:—"Characters of great value in one group or family are almost useless in the next; and all attempts at fixing certain characters as being of primary importance, others of secondary importance, and so on . . . lead to no result, *but we must get together our groups of species based upon as many characters as possible, and gradually build from them larger divisions*; and this process must be slow, but it will be natural, whereas the attempt to work from the larger divisions has led to false results." In a paper published in the Linnean Society's Journal, vol. xxvi, 1898, he tabulates all the available characters he can find (spines, avicularia, ovicells, communication-pores, frontal lamina, &c.) in 109 species of the extensive family Membraniporidæ, and sorts them into 15 groups, four being designated with generic names (e. g., *Onychocella* group) and the rest with some specific name (e. g., *patellaria* group).

Conscientious and painstaking work of this kind is of high value, not merely for purposes of identification of species, but also as an aid towards obtaining an insight into the relative value of the various characters from the point of view of natural affinities.

Mr. Waters often deplored the ruthless zeal of the priority purist sweeping away familiar landmarks to substitute others more ancient, it is true, but perhaps ill-defined and doubtfully interpreted; and further, he inveighed against the introduction of new terminology unless it was obviously necessary.

Mr. Waters worked on almost to the last. Even when he was over 80 years of age he published the fifth of a series of papers on the characters of the primary zoœcium or ancestrula and the mode of origin of the earliest zoœcia from it—a valuable piece of work, involving much patient search and observation.

With his immense experience of fossil and recent Bryozoa he had long become one of the leading authorities in the world.

His long life, though grievously handicapped by frail health, yet was devoted to arduous scientific research, and very certainly his work has earned for him from his fellow-workers a tribute of profound respect.

R. Kirkpatrick.

BENEFACTIONS.

LIST *in accordance with Bye-Laws, Chap.* XVII. *Sect.* 1, *of all Donations of the amount or value of Twenty pounds and upwards, received during the past Twenty years.*

1910.

Royal Society: Grant towards Dr. G. H. Fowler's paper on Biscayan Ostracoda, £50.

Sir Joseph Hooker: Gold watch-chain worn by Robert Brown, and seal with portrait of Carl von Linné by James Tassie.

Prof. J. S. Gardiner: Payment in aid of illustrations, £35 0*s.* 6*d.*

Sir Frank Crisp: Donation in Trust for Microscopical Research, £200.

The Trustees of the Percy Sladen Memorial Fund: Third grant towards publication of Prof. Stanley Gardiner's Researches in the Indian Ocean, £200. (For third volume.)

1911.

The Trustees of the Percy Sladen Memorial Fund: Second Donation towards the publication of the third volume on the Indian Ocean Researches, £70.

The same: First Donation towards the fourth volume, £130.

1912.

The Indian Government: Contribution towards the illustration of Mr. E. P. Stebbing's paper on Himalayan *Chermes*, £46 15*s.* 2*d.*

The late Mr. Francis Tagart, £500 free of Legacy Duty.

The late Sir Joseph Dalton Hooker, O.M., G.C.S.I., £100 free of Legacy Duty.

The Trustees of the Percy Sladen Memorial Fund: Second Donation towards the publication of the fourth volume on the Indian Ocean Researches, £140.

The same: First Donation towards the fifth volume, £60.

1913.

Royal Society: Grant towards Dr. R. R. Gates's paper on Mutating Oenotheras, £60.

Sir Frank Crisp, Bt.: Wallichian Cabinets, £50.

The Trustees of the Percy Sladen Memorial Fund: Second Donation towards the publication of the fifth volume, £200.

1914.

Royal Society: Grant towards Miss Gibbs's paper on the Flora of British North Borneo, £50.

Miss Foot: Cost of illustration of her paper on *Euschistus*.

The Trustees of the Percy Sladen Memorial Fund: Third Donation towards the fifth volume, £10.

The same: First Donation towards the sixth volume, £190.

1915.

The Trustees of the Percy Sladen Memorial Fund: Second Donation towards the sixth volume, £80.

Miss Foot: Cost of second paper on *Euschistus*, £32 10*s*.

Royal Society: Donations towards the cost of a paper by Mrs. Arber, D.Sc., £40.

The same: towards paper on Utakwa River plants by Mr. H. N. Ridley, C.M.G., F.R.S., £50.

Miss Marietta Pallis: Instalment of cost of her paper on Plav, £30.

Thomas Henry Riches, Esq.: Dr. A. R. Wallace's library on Natural History.

Sir Frank Crisp, Bt.: New shelving for Wallace's Volumes.

1916.

Mr. E. Heron-Allen: Contribution to cost of paper on Foraminifera of N.W. Scotland, £44.

Messrs. H. Takeda and C. West: Contribution towards the illustration of their paper, £40.

Royal Society: Contribution towards the illustration of two papers by Prof. Dendy, £40.

The same: Contribution towards Mr. Swynnerton's paper on Form and Colouring, £70.

The High Commission for the Union of South Africa, per Dr. J. D. F. Gilchrist, for the illustration of his paper on *Jasus Lalandii*, £30.

Miss Marietta Pallis: Balance of cost of her paper on Plav, £90 16*s*. 6*d*.

Sir Frank Crisp, Bt.: Phototyped copy of Dioscorides from the 'Codex Aniciæ Julianæ' at Vienna.

1917.

British Ornithologists' Union, etc.: Contribution towards cost of Mr. H. N. Ridley's paper, £20.

The Royal Society: Second contribution towards the printing of Mr. C. F. M. Swynnerton's paper on Form and Colouring, £75.

Sir Frank Crisp, Bt.: 'Lindenia,' Ghent, 1891–1901. 17 vols. sm. fol.

1919.

Dr. B. Daydon Jackson: MS. index to Linnean Society's Journal, Botany, vols. xxi.–xl. (1884–1912) and the Botanic entries in the 'Proceedings' for the same period.

1920.

The Royal Society: Third contribution towards the printing of Mr. C. F. M. Swynnerton's paper as above, £50.

The High Commission for the Union of South Africa, for the printing of Dr. J. D. F. Gilchrist's paper on *Jasus Lalandii*, Part II., £60.

1921.

The Percy Sladen Memorial Fund: Additional Grant in aid of publication of 'Transactions,' 2nd ser., Zoology, vol. xvii. part 4, £72 10*s*.

The same: Grant in aid of publication of four papers on the Houtman Abrolhos Islands, £100.

The Royal Society: Donation in aid of papers by Mr. N. E. Brown and Mr. S. L. Moore, £90.

Dr. W. Rushton Parker: Donation of a large series of portraits of Naturalists and Persons after whom Genera have been named, and work on rearrangement and annotation of the entire collection.

Prof. C. S. Sargent, F.M.L.S.: Eight volumes issued by the Arnold Arboretum including "The Bradley Bibliography."

Dr. B. Daydon Jackson: MS. Catalogue of each sheet in the Linnean Herbarium; bound in two volumes folio.

1922.

The late Sir Joseph Hooker: Donation of his Medals and Decorations. (Reversion to Linnean Society on Lady Hooker's decease.)

Anonymous donation in aid of publication of the late Dr. E. A. Newell Arber's paper, entitled "Critical Studies of Co Measure Plant-impressions," £60.

The Percy Sladen Memorial Fund: Cost of printing and illustrating 'Transactions,' 2nd. ser., Zoology, vol. xviii. pt. i.

1923.

Dr. W. Rushton Parker: (1) Donation of Oxford New English Dictionary; vols. i.–ix., vol. x. in parts, 4to, 1888–1923. (2) Encyclopædia Britannica; ed. XI. Cambridge, 1920–22. 32 vols. 4to.

E. Heron-Allen, Esq., F.R.S.: Contribution of £25 towards the cost of paper on the Foraminifera of Lord Howe Island.

1924.

The Percy Sladen Memorial Fund: Cost of printing and illustrating 'Transactions,' 2nd. ser., Zoology, vol. xviii. pt. ii.

1925.

An Anonymous Donor: New Presidential Chair, emblazoned with the Arms of the Society.

1926.

Subscription portrait of Dr. B. D. Jackson, R.N.O.

Mr. A. D. Michael: A large number of Books and Pamphlets from his Library.

The late Mr. A. O. Walker: £200 free of Legacy Duty.

An Anonymous Donor: £100 to establish a Fellowship in memory of the late Prof. E. A. Minchin, F.R.S., Sec.L.S.

The Royal Society: Donation in aid of publication of Mr. G. P. Farran's paper on Biscayan Plankton.—Part 14. The Copepoda, £60.

The late Mr. Frank Morey: £100 free of Legacy Duty.

The late Mr. George Lewis: Books and pamphlets on Entomological subjects.

Capt. E. G. Spencer-Churchill: A copy of a collotype reproduction of 'The herbal of Apuleius Barbarus . . . (MS. Bodley 130).'

The Percy Sladen Memorial Fund: Cost of printing and illustrating 'Transactions,' 2nd ser., Zoology, vol. xix. pt. i.

1927.

The late Mrs. Mary Anne Stebbing: £100 less Legacy Duty.

1928.

Carnegie United Kingdom Trust: £666 13*s.* 4*d.* for purchase of books.

The Royal Society: £160 (£85 in aid of the publication of Dr. G. Enderlein's paper on "Die Copeognathen der Seychellen," £75 in aid of Mr. C. V. B. Marquand's paper on "The Botanical Collections made by Capt. F. Kingdon Ward in the Eastern Himalaya and Tibet in 1924–25").

1929.

Carnegie United Kingdom Trust: £666 13*s.* 4*d.* for purchase of books.

The Percy Sladen Memorial Fund: £100 in aid of the publication of papers on the Fauna of the Paraguayan Chaco.

Carnegie Trust for the Universities of Scotland: £28 in aid of the publication of papers on the Fauna of the Paraguayan Chaco.

TREASURER'S ACCOUNTS FOR THE

(Presented at the Anniversary

Receipts and Payments of the Linnean Society

General

RECEIPTS.	£	s.	d.	£	s.	d.
To Balance at 1st May, 1928	604	3	3			
Do. deposits, Fellows' postal account	53	8	6			
„ Cash in hand	2	0	5			
				659	12	2
„ Admission Fees				52	0	0
„ Arrears of Annual Contributions	30	0	0			
„ Annual Contributions for year	2432	0	10			
Do. in advance	104	0	0			
				2566	0	10
„ Interest on Investments				260	12	8
Do. Deposit				15	18	3
„ Sales of Publications:—						
Transactions	49	12	7			
Journals	112	4	2			
Proceedings	12	8	9			
Library Catalogue	5	18	6			
				180	4	0
„ Donations from Royal Society in aid of Publications				160	0	0
„ Donation for General Purposes				1	0	0
„ Fellows' postal account, deposits				19	3	8
„ Miscellaneous Receipts				43	1	10

Income Tax not yet recovered £46 3 2.

£3957 13 5

Library

RECEIPTS.	£	s.	d.
To Balance 1st May, 1928	79	4	11
„ Interest on Investments	39	19	4
„ Carnegie United Kingdom Trust—2nd Third of £2000 Grant	666	13	4
„ Transferred from General Account	733	6	8

Income Tax not yet recovered £10 0 0.

£1519 4 3

YEAR ENDED APRIL 30TH, 1929.

Meeting, May 24th, 1929.)

from May 1st, 1928, to April 30th, 1929.

Account.

PAYMENTS.	£	s.	d.	£	s.	d.
By House Expenditure:—						
Coal		60	8	3		
Electric Current	£26	14	3			
Electrical Repairs	10	4	10			
		36	19	1		
Furniture		53	5	0		
Gas		23	7	4		
Repairs, sundry		19	11	1		
Sundry payments		41	11	9		
Taxes and Insurance		33	0	2		
Tea at Meetings		35	17	1		
					303	19	9
„ Linnean Collections; Repairs					14	17	3
„ Office Expenditure:—						
Miscellaneous Printing		258	19	6		
Postages and Sundry Expenses		114	2	10		
Stationery		54	16	8		
					427	19	0
„ Publications:—						
Printing		832	5	9		
Illustrations		166	9	7		
Distribution		45	4	4		
					1043	19	8
„ Salaries and Wages, etc.					1097	17	9
„ Transferred to Library Account		.....			733	6	8
„ Percy Sladen Memorial Fund—Donation in aid of Dr. G. Enderlein's Paper		.....			85	0	0
„ Linnean Medal		.....			15	0	0
„ Fellows' postal account		.....			6	5	6
„ Balance at 30th April, 1929		151	4	5			
Do. Fellows' postal account deposits		66	6	8			
„ Cash in hand		11	16	9			
					229	7	10
					£3957	13	5

Account.

PAYMENTS.	£	s.	d.
By Books	500	16	6
„ Periodicals	410	14	3
„ Binding	570	11	1
„ Balance of 30th April, 1929	37	2	5
	£1519	4	3

Separate Account.

	£	s.	d.		£	s.	d.
To Balance at 1st May, 1928 :—				By Hooker Lecture Fund:—			
Westwood Fund £36 6 0				Award and Expenses to Lecturer	31	10	0
Trail Award Fund 10 4 2				,, Goodenough Fund :—			
Crisp Award Fund 9 4 7				Transferred to General Account.....	12	0	0
Hooker Lecture Fund 70 16 4				,, Annual Dinner Fund :—			
Goodenough Fund 12 6 6				Cost of Annual Dinner 29 15 0			
Linnean History Fund..... 21 9 6				Cost of Anniversary Meeting Dinner 24 4 6			
	160	7	1		53	19	6
,, Annual Dinner Fund Receipts 29 15 0				,, Minchin Fellowship Fund :—			
,, Anniversary Meeting Dinner Receipts... 24 4 6				Transferred to Annual Contributions	4	0	0
	53	19	6	,, Conservatoire botanique de Genève :—			
,, Conservatoire botanique de Genève :—				Subscriptions paid over	8	2	0
Subscriptions collected.....	8	2	0	,, Balance at 30th April, 1929 :—			
,, Interest on Investments :—				Westwood Fund £45 4 10			
Westwood Fund £8 18 10				Trail Award Fund 13 14 2			
Trail Award Fund 3 10 0				Crisp Award Fund 16 14 7			
Crisp Award Fund 7 10 0				Hooker Lecture Fund..... 60 18 8			
Hooker Lecture Fund 21 12 4				Goodenough Fund 4 15 8			
Goodenough Fund 4 9 2				Linnean History Fund..... 21 9 6			
Minchin Fellowship Fund 4 0 0					162	17	5
	50	0	4				
Income Tax not yet recovered £2 12 0.							
	£272	8	11		£272	8	11

Investments on April 30th, 1929.

£ s. d.			Market Value, 30th April, 1929. £ s. d.
	General Account.		
1000 0 0	Metropolitan 3 per cent. Stock 1941	@ 83	830 0 0
1200 0 0	India 3 per cent. Stock	@ 58½	702 0 0
1000 0 0	Eastern Bengal Railway 4 per cent. Irredeemable Debenture Stock	@ 78	780 0 0
1000 0 0	Great Western Railway 4 per cent. Debenture Stock	@ 81½	815 0 0
312 0 0	London Midland & Scottish Railway 4 per cent. Preference Stock	@ 70	218 8 0
3296 0 0	4½ per cent. Conversion Stock 1940–44	@ 98½	3246 11 2
			£6591 19 2
	Library Account.		
£ s. d.			£ s. d.
450 0 0	Forth Bridge Railway 4 per cent. Stock (Bentham Bequest)	@ 80	360 0 0
200 0 0	4½ per cent. Conversion Stock 1940–44 (Walker and Morey Bequests)	@ 98½	197 0 0
530 0 0	East Indian Railway 3½ per cent. Debenture Stock (Tagart Bequest)	@ 67½	357 15 0
88 9 8	London County 5 per cent. Stock 1940–60 (Stebbing Bequest)	@ 102	90 5 1
			£1005 0 1
	Separate Account.		
£ s. d.			£ s. d.
£912 9 5 — 232 5 0	Metropolitan Water Board 3 per cent. "B" Stock (Westwood Fund)	@ 64	148 12 10
638 4 5	Ditto ditto (Hooker Lecture Fund)	@ 64	408 9 2
42 0 0	Ditto ditto (Goodenough Fund)	@ 64	26 17 7
100 0 0	New South Wales 3½ per cent. Stock, 1930–50 (Trail Award Fund)	@ 75	75 0 0
300 0 0	2½ per cent. Consolidated Stock (Crisp Award Fund)	@ 55	165 0 0
£200 0 0 — 50 0 0	4 per cent. Victory Bonds (Westwood Fund)	@ 93	186 0 0
50 0 0	4 per cent. Victory Bonds (Hooker Lecture Fund)		
100 0 0	4 per cent. Victory Bonds (Goodenough Fund)		
100 0 0	London County 5 per cent. Stock 1940–60 (Minchin Fellowship Fund)	@ 102	102 0 0
			£1111 19 7

HORACE W. MONCKTON, *Treasurer.*

We have (in conjunction with the Professional Auditor, who certifies as to all details) audited the Accounts of the Society for the year ended 30th April, 1929, and found them correct. We have verified the Investments and Bank Balances.

Dated this 14th May, 1929.

W. B. KEEN, *Chartered Accountant.*

S. F. HARMER,
J. RAMSBOTTOM,
I. HENRY BURKILL,
FRANCIS DRUCE,
EDWARD T. BROWNE,
D. J. SCOURFIELD,
Auditors.

ADDITIONS AND DONATIONS

TO THE

LIBRARY.

1928–1929.

Note.—Separate copies of papers which are included in periodicals received by the Library are no longer catalogued. Names of donors are given in square brackets. The sizes are given in centimetres,—to the nearest centimetre.

Abel, Othenio. Lebensbilder aus der Tierwelt der Vorzeit. 2 Aufl. *Jena*, 1927. 25×17.

Acosta, Christobal. Aromatum et medicamentorum in Orientali India nascentium liber . . . *Antverpiæ*, 1582. 15×10.

Acta Universitatis Asiæ Mediæ. Series viii. *a.* Zoologia, Fasc. 1→ 26×17. *b.* Botanica, Fasc. 1→ 26×17. *Taschkent*, 1927–28→.

Agardh, Carl Adolph. Aphorismi Botanici [16 parts]. *Lundæ*, 1817–26. Classes Plantarum [2 parts]. *Lundæ*, 1825. [In 1 Vol.] 19×11.

Albertus Magnus. De vegetabilibus libri septem. Historia Naturalis, pars xviii. *Berolini*, 1867. 22×14.

Alcock, A. A Naturalist in Indian Seas: or, Four Years with the Royal Indian Marine Survey Ship 'Investigator.' *London*, 1902. 23×15.

Allan, H. H. New Zealand Trees and Shrubs, and how to identify them. *Auckland*, [1928]. 18×12.

Allen, E. J. *See* **Fowler, G. Herbert.**

Ames, Oakes. Orchidaceæ: Illustrations and Studies of the Family Orchidaceæ. *Ames Bot. Lab. N. Easton, Mass.* Fasc. 1–7. *Boston*, 1905–1922. 25×18. [Author.]

—— Schedulæ Orchidianæ. Nos. 1–9. *Boston, Mass.* 1922–25. 22×14. [Author.]

Andrews, Charles William. On a Specimen of *Elephas antiquus* from Upnor. *London*, 1928. 31×25. [Trustees Brit. Mus.]

Angus, George A. Linnæus—Prince of Botanists. *The Philosopher*, *London*, Jan.–Mar. 1929. 21×14. [Author.]

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Anthony, H. E. Field-Book of North American Mammals. *New York*, 1928. 17×10. [Publishers.]

Antarctic Expeditions. *See* **Deuxieme Exped. Antarct.**; and **Exped. Antarct. Française.**

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Arnold, F. H. Flora of Sussex . . . new [2nd] edition, with numerous additions. *London*, 1907. 18×12.

Aslib Directory (The). A Guide to Sources of specialized information in Great Britain and Ireland. Edited by G. F. Barwick. *London*, 1928. 28×18. [Assoc. Spec. Libr. and Inf. Bureau.]

Austen, E. E. The House-fly: its Life-history. Economic Series, No. 1 *a*. 3rd ed. *London*, 1928. 21×14. [Trustees Brit. Mus.]

Australasian Antarctic Expedition, 1911–14. Scientific Reports. Series A→, B→, C→ *Adelaide*, 1916→ 31×25.

Bailey, Vernon. Animal Life of the Carlsbad Cavern. Monogr. Amer. Soc. Mamm. No. 3. *Baltimore*, 1928. 20×14.

Baker, E. C. Stuart. The Fauna of British India: Birds, Vol. v. Ed. 2. *London*, 1928. 23×16. Vol. vi. Ed. 2. *London*, 1929. 23×16. [The India Office.

Baker, J. G. *See* **Burbidge, F. W.**

Balfour, John Hutton. Flora of Edinburgh . . . *Edinburgh*, 1863. 17×11.

Banks, Sir Joseph. *See* **Maiden, J. H.**; **Hermannson, Halldór.**

Barbosa Rodrigues, João. Sertum Palmarum Brasiliensium, ou relation des Palmiers nouveaux. Pts. 1 & 2. *Bruxelles*, 1903. 61×44.

Barratte, G. *See* **Bonnet, Ed.**

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Bateson, William: his Essays and Addresses, together with a short account of his life, by Beatrice Bateson. *Cambridge*, 1928. 22×14.

Bather, F. A. Rhodesian Man and associated remains: contributions from various authors and an introduction by F. A. Bather. *London*, 1928. 31×25. [Trustees Brit. Mus.]

Battiscombe, E. A descriptive catalogue of some of the common trees and woody plants of Kenya Colony. *London*, [1926]. 23×18.

Baxter, Evelyn V., & Rintoul, Leonora J. The Geographical Distribution and Status of Birds in Scotland. *Edinburgh*, 1928. 23×15. [The Authors.]

Baylis, H. A. A Manual of Helminthology, medical and veterinary. *London*, 1929. 23×16.

Beccari, Odoardo. Nuova Guinea Selebes e Molucche. Diarii di Viaggio. *Firenze*, 1924. 26×18.

Beer, G. R. de. Vertebrate Zoology: an introduction to the comparative anatomy, embryology, and evolution of chordate animals. *London*, 1928. 22×14. [Author.]

Beissner, L. Handbuch der Coniferen-Benennung: Systematische Einteilung der Coniferen. Ausgearbeitet von L. Beissner. *Erfurt*, 1887. 22×15.

Bell, J. H. Methods of Moth Collecting. *London*, [n.d.]. 18×12. [Author.]

Bezzi, Mario. Diptera Brachycera and Anthericea of the Fiji Islands. *London*, 1928. 22×14. [Trustees Brit. Mus.]

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Blackwell, E. W. *See* **Laing, R. M.**

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Borg, John. Descriptive Flora of the Maltese Islands, including the Ferns and Flowering Plants. *Malta*, 1927. 21×15.

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PRINTED IN GREAT BRITAIN BY TAYLOR AND FRANCIS,
RED LION COURT, FLEET STREET.

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